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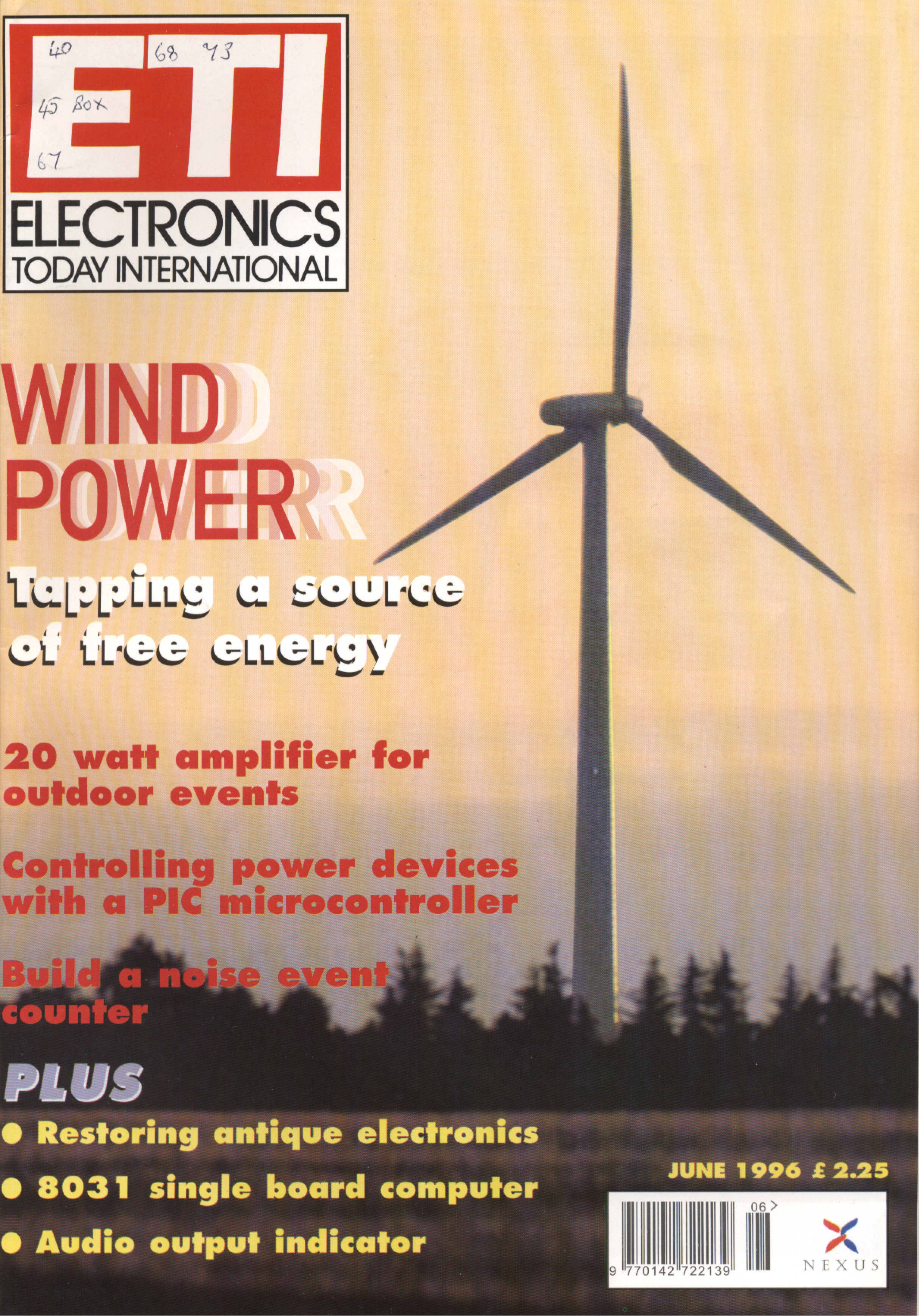

WIND POWER

Tapping a source of free energy

20 watt amplifier for outdoor events

Controlling power devices with a PIC microcontroller

Build a noise event counter

PLUS

- Restoring antique electronics
- 8031 single board computer
- Audio output indicator

JUNE 1996 £ 2.25

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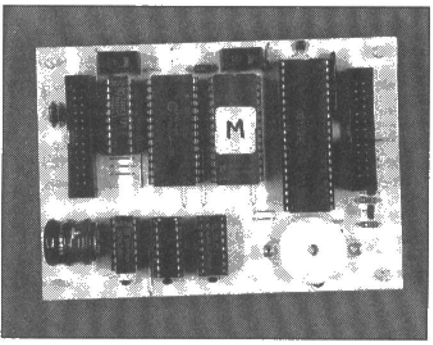

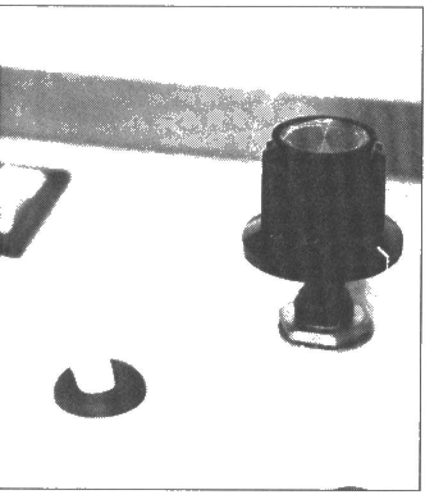

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News...

PDSL announces new CD ROM

PDSL, The Public Domain and Shareware Library, today announced the release of its new CD ROM, The Scientific and Technical Library. This CD includes a collection of hard to find scientific, technical and specialist applications for DOS and Windows.

"Normal retail software cannot offer the variety of technical and specialist programs which are compiled on this disc", said Rod Smith, who has run the Public Domain and Shareware Library for 12 years. "Experts will find programs on Artificial Intelligence, Astronomy, Communications, Education, Electronics, Engineering, Graphics, Ham Radio, Mathematics, Programming, Chemistry, Security, Special Needs, Technical Drawing, Text Editing and Utilities. This is a long list of categories and there is a tremendous variety. We provide an easy to use viewing program and even a novice could quickly be able to navigate through the listings in order to find a specific file or program".

The Scientific and Technical Library CD ROM with over 2,000 listed working programs costs just £29.00 and is available by mail order or by phone on Visa or Access.

Contact PDSL, Winscombe House, Beacon Road, Crowborough TN6 1UL. Tel: 01892 663298.

Milli-Ohm add-on for DVM

Sutronics recently announced a new range of test equipment launched as a spin-off from their successful Power Control Products. The latest in the range is a Milli-ohm test meter designed as an add-on to a D.V.M. and features sensitivity as low as 100μΩ. With an accuracy of typically _+0.1%. Measuring from 0.1mΩ to 20Ω, this makes it ideal for measuring current sense resistors, PCB track resistance, cable lengths, short circuit distance calculations, meter shunts, fault finding on PCBs, motor armature resistance etc.

Contact Sutronics on 01929 426400.
Http://www.bucc.co.uk/vbp/sutronics. ▼

New PIC programmer

The New "PIC PRO" from 3 R Cardware is capable of reading and writing data to and from the popular PIC16C84 microchip, a low cost, fully reprogrammable, EEPROM-based microcontroller that can be found in many commercial and consumer applications.

The PIC PRO was developed by 3R Cardware for the satellite market to enable satellite dealers to upgrade D2MAC viewing cards for which the PIC 16C84 microchip is used to process encrypted algorithms, transmitted within the satellite signal.

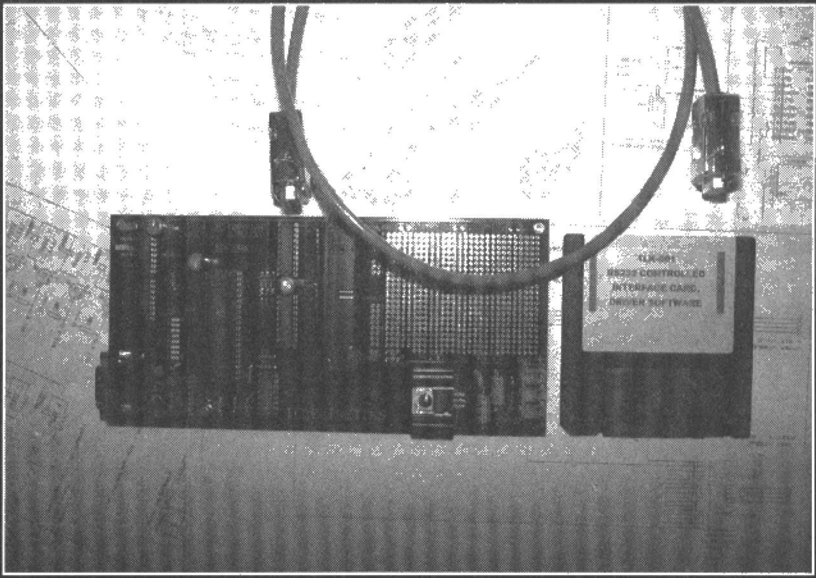
The unique selling point of the "PIC PRO" is that it is able to "deprotect" the fuse protection set by the original programmer of the chip and allow the entire date area of the chip to be read.

The PIC PRO is presented on a professionally made PCB and can facilitate a single chip via an IC socket or address a chip mounted on a PCB via a standard IS07816 smart card reader.

Each programmer comes together with power supply, parallel data cable and menu driven software for £99 +VAT.

For further information please contact 3R Cardware on 01246 455150 or 01246 455945."

PC add-ons

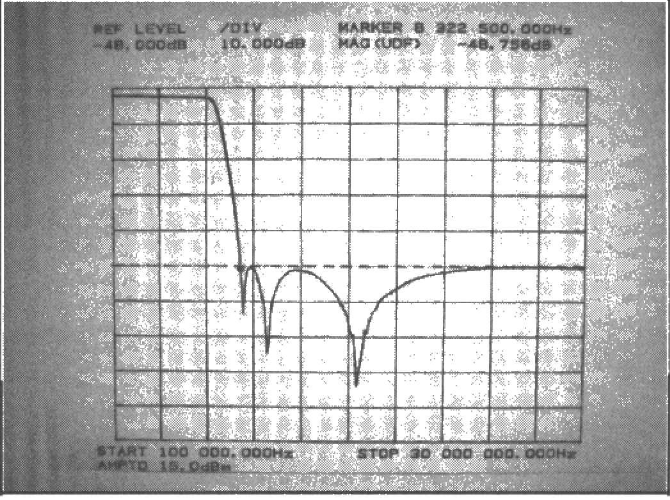


Telekinetiks recently introduced three products for the IBM PC and compatibles. The first is an RS232 controlled interface card (£69) that can be used to control a variety of peripheral devices. Apart from the usual two 8 bit I/O parts, there are also two strobe lines for optional handshaking. For example most A/D converters require a start conversion pulse and produce an end conversion pulse when the input signal has been digitised.

The output pulse strobe can also be used to latch outgoing data for multibyte applications. Baud rates are easily selectable via a dip switch. The board also has a prototyping area together with a 40-way IDC connector for off-board applications. The application notes cover everything from digitising light intensity to AC power control. Software is supplied in source code form. The board also comes with a standard RS232 Null modem cable so it can easily be moved from one PC to another.

The second item is an elliptic filter synthesis package (£25) which features Active, Passive, Low pass, High pass and Band pass. The final item is a sound amplifier (£15) which fits inside the system case, with power supplied from an unused 5.25 inch disk drive power connector. Gain is variable up to 20dB.

Contact Telekinetiks on 01782 662099.



Low-cost GPS clock

Sematron UK Ltd have just announced a high accuracy, low-cost clock which obtains its timing reference from the GPS satellite system.

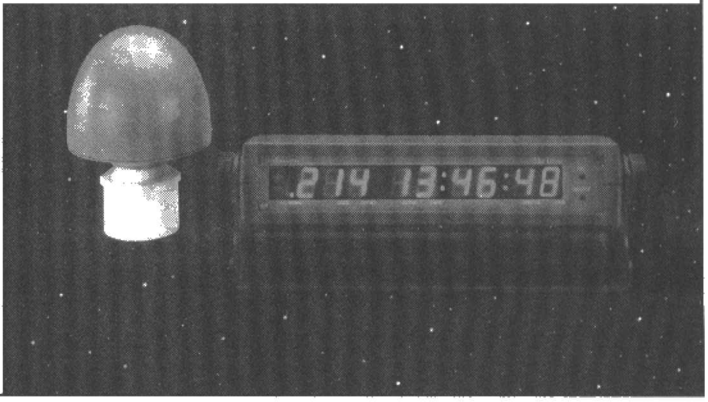
The new clock designated 'StarTime' is yet another product from Sematron who now offer the most complete range of GPS-based frequency and timing products in the UK through their representation of Datum Inc. Within the Datum group are industry standard names such as Austron, Bancomm, Datum Timing, Efratom and FTS - companies who are involved in almost every aspect of frequency and timing in GPS systems.

'StarTime' provides a standard IRIG B (AC & DC) time code output, a reference lpps (50us pulse) and is complete with a 9600 Baud RS-232C interface. With current Selective availability, timing accuracy is better than 2us and positional accuracy better than 100 metres SEP. Maximum operational velocity is 400 metres/sec. Under brief power off conditions the time for a first fix is less than 1.5 mins, worst case conditions 5 to 15 mins. Operation is fully automatic from Power-On, with default settings being user-programmable via the RS-232C interface.

Applications for 'StarTime' are very wide ranging, but primarily focussed on cost-sensitive applications where an IRIG B timing signal is required without the need for frequency references. In general, the range of GPS clocks and frequency references are used for Telecomms synchronisation, Military Test Ranges, Power Utilities, Cellular systems, Computer Network time synchronisation, Laboratory time and frequency standards, Airborne instrumentation systems, Astronomy and Seismic research.

This compact unit measures 41mm x 188mm x 71mm and is supplied complete with a 77mm dia x 77mm high satellite antenna, 15 metres of antenna cable, AC power adapter and two user manuals.

For further information contact Sematron UK Ltd on 01256 812222



New family of high performance 0.35 micron cell-based ASICs

NEC Electronics has unveiled CB-C9, its first family of 0.35 micron drawn (0.27 micron effective) cell-based ASICs. They provide a 22 percent increase in performance over 0.5 micron CMOS cell-based ICs and a 45 percent reduction in power consumption.

The low power consumption and performance of the CB-C9 family makes it ideal for low power consumer applications such as personal digital assistants and set-top boxes as well as for high-end designs such as engineering workstations and peripherals.

The CB-C9 family is supported by NEC's OpenCAD design system which allows designers to mix and match tools from a variety of electronic design automation vendors with NEC's proprietary tools. The OpenCAD system aids designers throughout the ASIC development.

The CB-C9 family operates at 3.3 volts and utilises NEC's advanced three-layer metal CMOS process. It offers 25 sizes ranging from 80,000 to 3,900,000 raw gates (56,000 to 1,600,000 used gates)

Performance is 113 picoseconds for 2 NAND gates loaded with two fan-outs and 0.4 millimetre of wire, enabling the CBC9 Co support target systems speeds of up to 1S0MHz. Increased performance and variable sizes offered with the CB-C9, enable users to create a system on a chip designs, which in turn provides higher reliability due to fewer parts. Future versions will also support 2.5 volt and 2.0 volt supply standards used in the 7th and 8th generation of CPUs. The CB-C9 family has a power dissipation of 0.7 uW/MHz/gate at 3.3 volts and 0.5uW/MHz/gate at 2.5 volts, thereby reducing power consumption while obtaining the higher speed frequencies needed for high end applications.

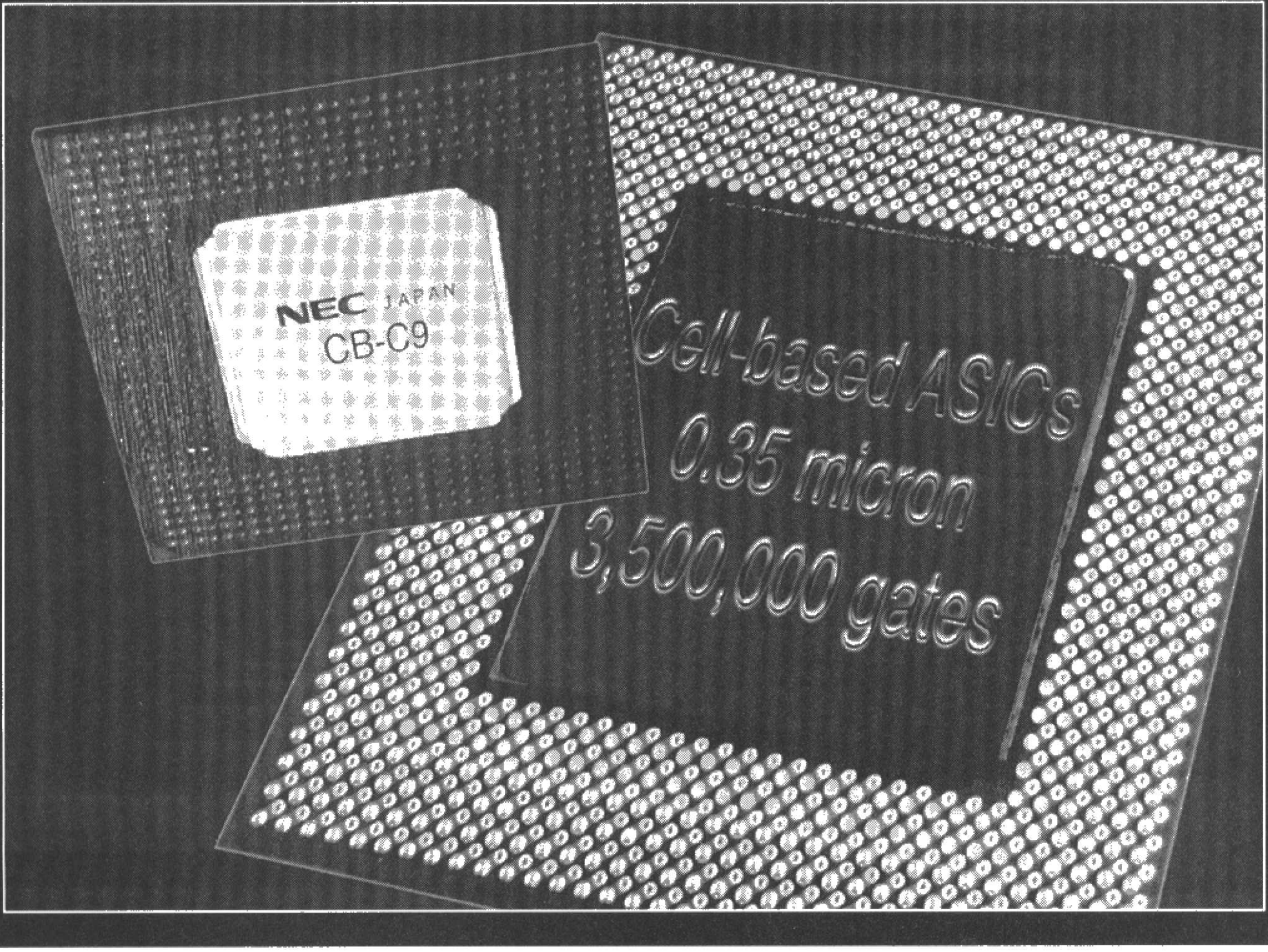
Additional features include 200MHz phase-locked loops (PLL) for accurate on-chip clock generation and synchronisation, and compiled high-speed RAM and ROM, enabling designers to optimise on-chip memory size for each application.

The CR-C9 family supports a variety of I/O interfaces including 5 volt tolerant interface for mixed voltage designs, a 66MHz PCI I/O at 3.3 volts, and a full range of low-voltage transistor-to-transistor logic (LVTTL) interfaces.

Future library updates will include support for high speed I/O such as high speed transceiver logic (HSTL), Gunning transceiver logic (GTL) and pseudo emitter coupled logic (pECL). For mixed voltage applications, CB-C9 also supports a special voltage level shifter cell which converts external 3.3 volt I/O signals to 2.5 volts or 2.0 volts to interface with internal logic.

The CB-C9 family offers a pad count range from 104 to 1200 whilst packaging options include plastic quad flat pack (PQFP), plastic ball grid array (PBGA) and tape ball grid array (TapeBGA). Thermal management features such as heat spreader and beat sink are also available.

For further information contact: NEC Electronics (UK) Ltd, Milton Keynes. Tel: 01908 691133



New 150MHz Pentium SBC with a PCI bus integrated SVGA controller.

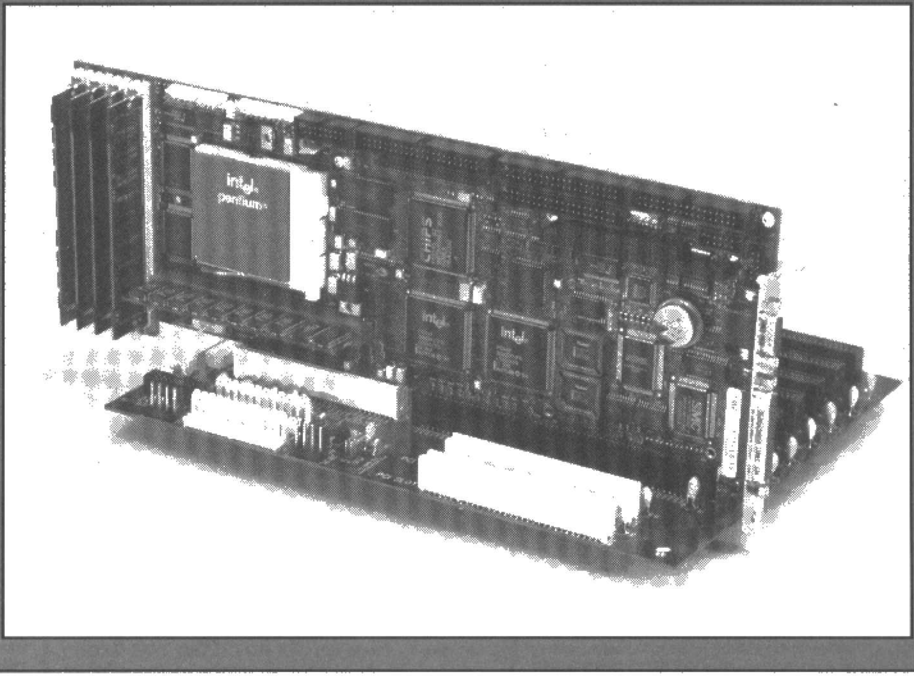
The AMC-2105 combines a 150MHz Pentium processor with on-board Chips & Technologies 65545 CRT/Flat Panel controller supporting Bit Block transfer and GUI accelerator features. The graphics interface is on the PCI local bus providing optimal graphics performance.

Resolutions ofup to 1280 x 1024 pixels can be supported with 1MB of video RAM. To achieve this the 2105 is one of the first passive backplane SBCs to utilise the Intel TRITON chipset.

In addition, the 2105 provides two full 16C550 serial ports, printer port with ECP support, floppy and dual enhanced IDE support as part ofthe standard I/O package. Memory capacity is up to 128MB with 64 Bit wide RAM and the architecture can support EDO RAM to allow pipeline burst memory transfers for further enhanced performance. The board includes up to 512KBytes of synchronous write-back cache.

The 2105 also incorporates the latest embedded PC and system BIOS features such as temperature sensing for processor clock speed reduction - no fan required for speeds up to 90MHz. The MTBF ofthe 2105 is not less than 90,000 hours.

For more information contact: Advanced Modular Computers Ltd on 01753 580660



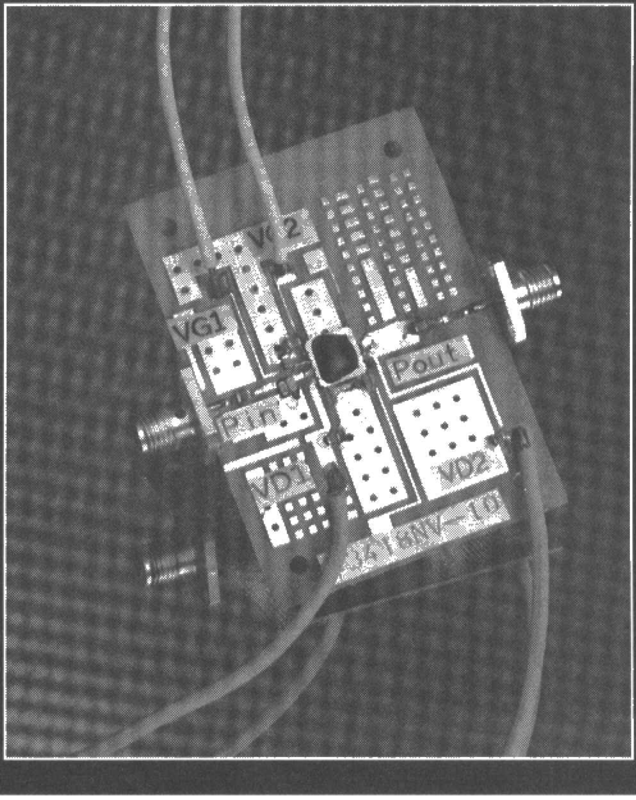
High Output Power, Reduced Size, PCN GaAs MMIC Power Amplifier

Mitsubishi is announcing the introduction of the MGF7150C GaAs MMIC power amplifier featuring a five cell construction operating at 4.7V. The device is available now in a 7x7mm, 8pin leadless ceramic package. Further developments include a plastic packaged version which is expected in Q3 and a four cell construction device is expected to be available in Q4 this year.

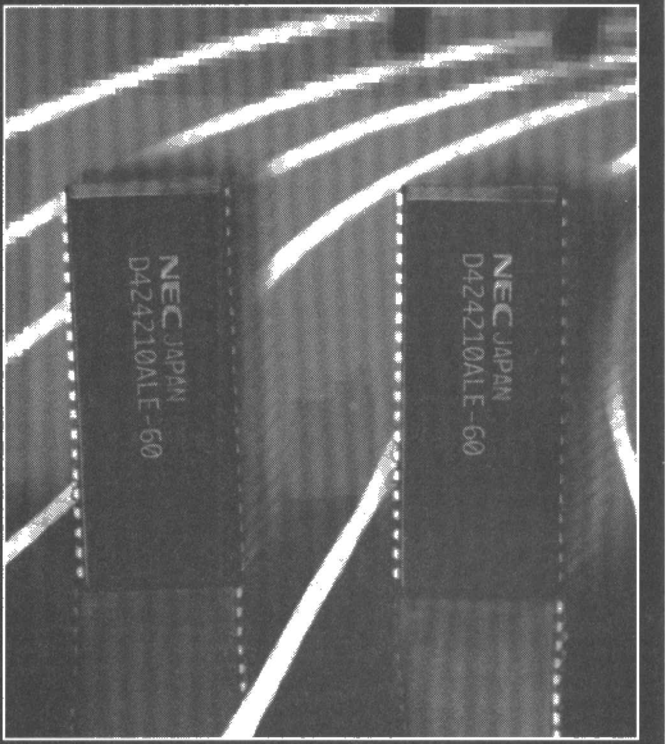
The MGF7150C devices come in surface-mount packaging and provide a cost-effective and PCB space saving solution to PCN handheld telephones and RF power amplification DCS1800 applications. The new designs are less than 25% of the size of Mitsubishi's previous PCN power amplifier solution. The 1.8GHz monolithic device provides a high output power of greater than or equal to 33dB. The high power gain design provides a high power added efficiency of >40%.

As part of the options for PCN and other telecomms applications, Mitsubishi is currently assessing the market requirement for GaAs power amplification ICs to provide OEMs with the devices with or without output matching circuits. MMICs without output matching circuits substantially reduce the device size and enable OEMs to further reduce the size of their products and equipment.

For further information contact Mitsubishi Electric UK Ltd, Semiconductor Division, Hatfield. Tel: 01707-276 100



New NEC 4MB EDO DRAM



NEC Electronics' new 4MB Hyperpage DRAM provides a 38% increase in bandwidth over standard (fast page) products when used in graphics applications. The uPD424210A device, which is formatted as 256K x 16, is pin-for-pin compatible with standard DRAMs, yet has a page mode cycle time of only 25 nanoseconds. The uPD424210A maintains valid data on its output even after the CAS (column address strobe) has been toggled to a high state, enabling the data to be used during the CAS pre-charge time. The benefit of this architecture is that it allows the cycle time to be reduced to 25ns, further increasing overall bandwidth. Because of their increased bandwidth and compatibility with fast page devices, EDO DRAMs are expected to become the preferred device over the next two years as designs are changed to capitalise on the increased performance. By virtue of its 256K x 16 format, the uPD424210A is particularly suited to graphics applications where long strings of 16 bit words are often accessed sequentially. In comparison with fast page DRAMs, which would take around 20.6 microseconds to access 512 words from the same page, the uPD424210A would take only 12.8 microseconds. The uPD424210A is supplied in 44-pin plastic TSOP(II) and 40 pin SOJ packages.

For further information contact NEC Electronics (UK) Ltd, Milton Keynes. Tel: 01908 691133

3 Phase Harmonic Analysis

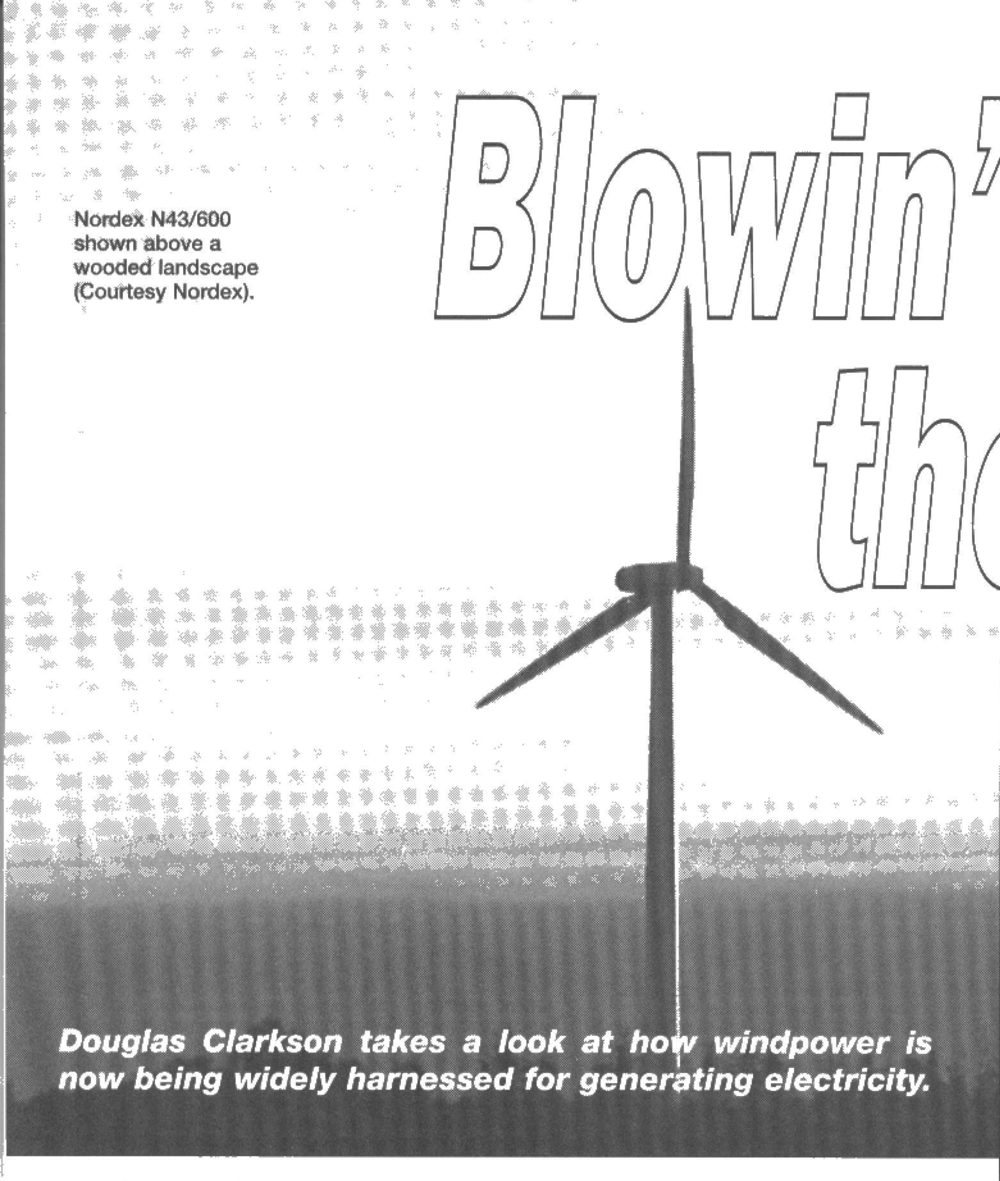
Harmonic Distortion continues to be a major concern for both industrial and commercial power consumers, as well as for power generators. As more and more products and systems use switching power supplies and thyristor drives, the potential damage caused by poor power quality resulting from induced harmonic voltages and currents increases,

Now available from all members of the Professional Instrument Distributors Association is the Fluke 41B Power Harmonics Analyser. At the touch of a key, the 41B can measure true rms voltage and current, frequency, and determine power factors with three phase power readouts. Measurements can be viewed in three ways: as a waveform; as a bargraph showing the level of harmonics present; or as a numeric value. All data can be captured in the Record mode and quickly and easily downloaded.

The Power Harmonics Analyser brings a new generation of analytic support to the design and maintenance of efficient power systems. It gives both engineers and consultants direct measurements, data storage, and computer interface to home in on harmonics, optimise power system performance, improve power quality and analyse system data.

The Fluke 41B Power Harmonics Analyser costs(ex VAT) £1,695.00. For further information contact the Professional Instrument Distributors Association on 01756 799737

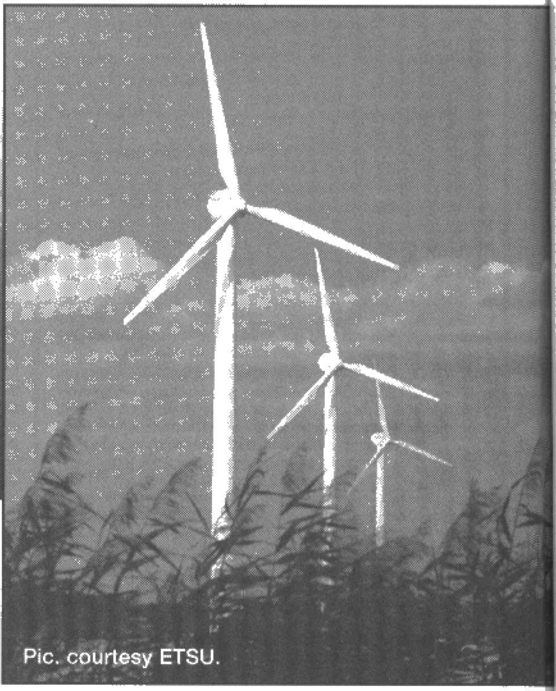
Blowin' in the Wind



Nordex N43/600 shown above a wooded landscape (Courtesy Nordex).

Douglas Clarkson takes a look at how windpower is now being widely harnessed for generating electricity.

It is only in the closing years of the 20th century that the concepts of the supply and demand of energy within the world are coming into a clearer focus. When, for example, in the 1960s most of the world's major economies began to expand rapidly after the period of austerity following the second world war, energy was a simple concept. The bottom line was its price and availability. There were then no drawbacks (such as acid rain and global warming) to the continued use of fossil fuels. These concepts would come to the fore much later. Nuclear power was rapidly expanding, primarily in countries which produced nuclear weapons. In the absence of any details in the public domain of nuclear accidents, the public as a whole did not worry about living ten miles down wind of a nuclear power installation. Now some ten years on from the Chernobyl nuclear accident, significant long term medical effects are only now coming to light among the exposed population. The perspective on energy is rapidly changing as a broad base of scientific knowledge causes a re-assessment of environmental factors in energy provision. It should be recognised that this shift in perspective is on-going and that the pendulum is beginning to shift in the direction of environmental responsibility. The article on solar photovoltaic technology (ETI, March 1996) indicated how there exists a sure and certain future for energy production using solar generated electricity. Likewise, this article will review the recent developments in technology which will usher in rapidly increasing utilisation of wind power. While the USA at one time had the largest installed capacity, the lead is now with Europe - indicating that it has in many ways decided to implement the technology on a 'serious' scale.



Pic. courtesy ETSU.

Where we are

Figure 1 indicates that Europe, like most of the world, is still locked into the use of fossil fuels. In terms of relative source of carbon dioxide, the principal 'greenhouse gas', figure 2 shows the major categories of its production within Europe. By the same token, figure 3 indicates the breakdown of sulphur dioxide production - the origin of acid rain - within Europe. In this context, the energy industry is the main producer of both serious pollutants. The THERMIE initiative within the European Community is designed to try to stabilise the greenhouse gas production of the European Community at 1990 levels by the year 2000. Figure 4 shows how carbon dioxide emissions can be stabilised using so called Best Available Technology options - and also what may happen if the concept of THERMIE is not realised. Within the countries of the EC, wind power is a key player in the THERMIE initiative and is rapidly being developed as a means of generating pollution-free power and also one that is already argued to be cheaper than conventional thermal/nuclear power generation.

Pollution savings

Table 1 indicates some basic facts about power generation and emission of pollutant gases. Carbon dioxide emission savings are considered to range from 0.8 kg/kWh to 1.1 kg/kWh depending on the nature of the fossil fuel being displaced.

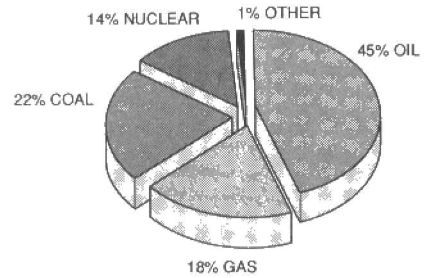


Fig. 1: Source of energy utilisation in Europe - showing dependence on fossil fuels (Courtesy THERMIE)

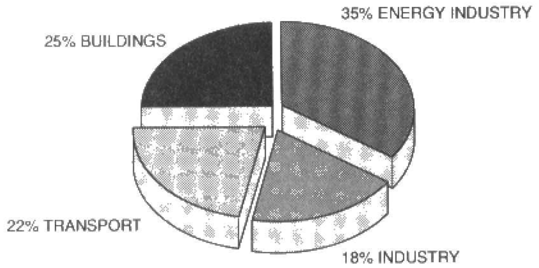


Fig. 2: Principle sources of Carbon Dioxide in Europe. (Courtesy THERMIE)

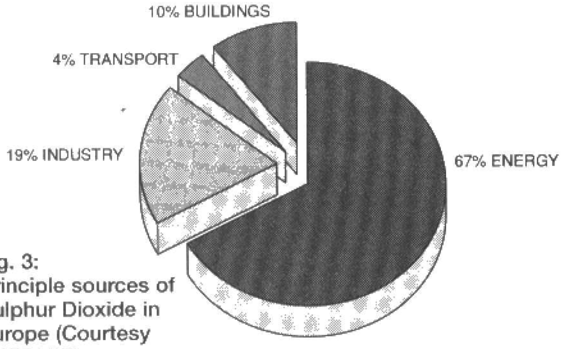


Fig. 3: Principle sources of Sulphur Dioxide in Europe (Courtesy THERMIE)

Emission	Mass of emission saved per kWH (grammes)	Annual savings 5 MW scheme (tonnes)	Annual savings 200 MW scheme (tonnes)
Carbon Dioxide	800	13,300	532,000
Sulphur Dioxide	10	195	8000
Nitrogen Oxides	3.4	65	2600

Table 1: Estimate of typical saving of emission gases for specific rates of energy production using wind power.

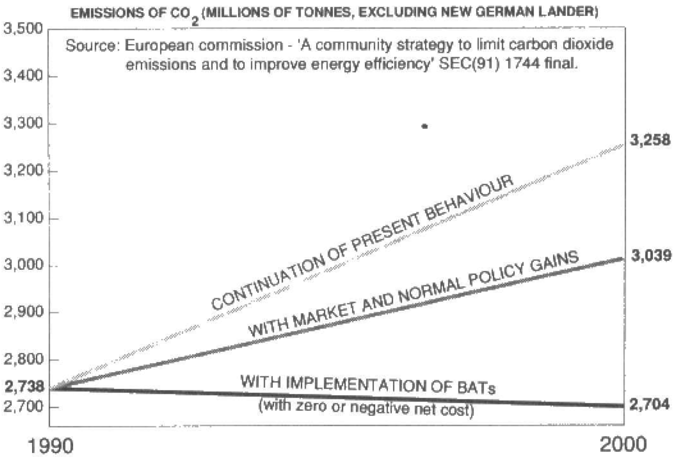


Fig. 4: Carbon Dioxide production scenarios within Europe up to the year 2000. (Courtesy THERMIE)

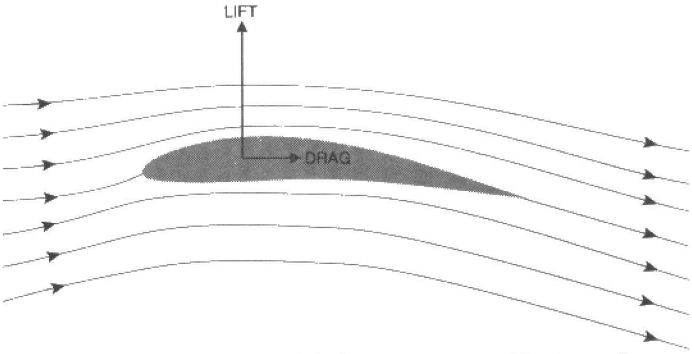


Fig. 6: Bernoulli's principle of air flow across rotor. The faster flow on one side causes a reduction in pressure which gives an uplift force on the rotor. (Courtesy BWEA)

Since wind power creates no atmospheric emissions the utilisation of wind power can be directly used to reduce the emission of carbon dioxide. In Denmark where 8% of energy utilised was renewable and with a 6% contribution from wind power, overall carbon dioxide emissions fell by 1.3% during 1993.

Basics of wind generators

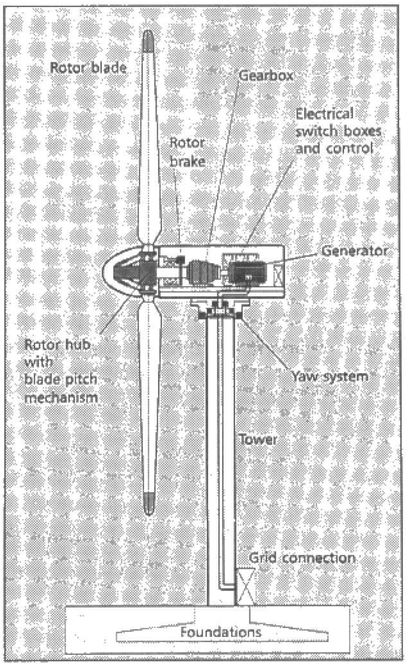
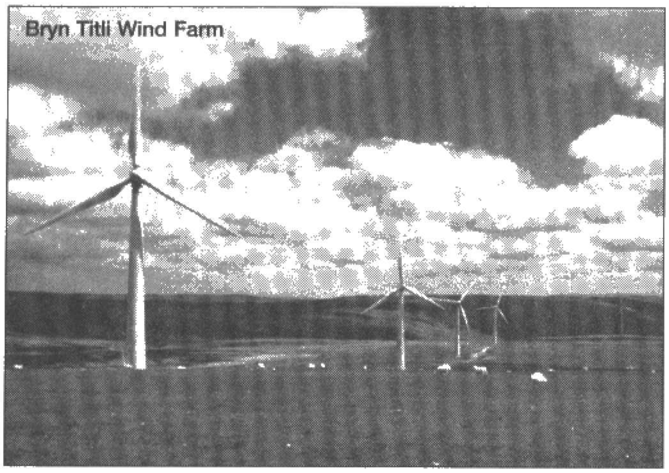
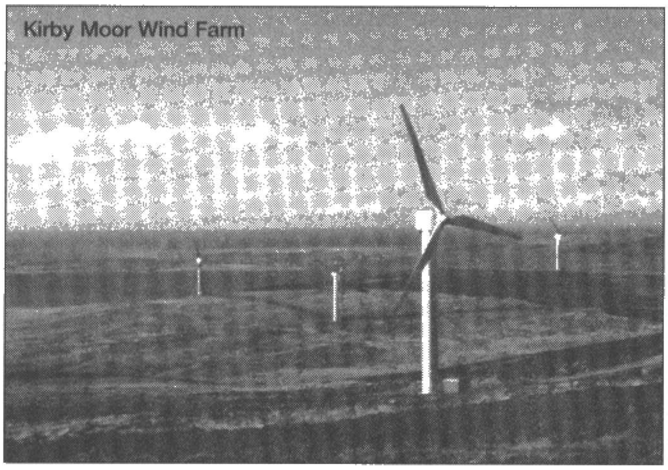


Fig. 5: Typical horizontal wind turbine (Courtesy BWEA)

At present schemes to abstract this energy rely on ground-based wind generators. A typical horizontal wind turbine is shown in figure 5. Figure 6 shows how, by Bernoulli's principle, air flow across a typical cross section of a rotor blade results in a lift force and a drag force. The blade is designed so that air flow over the upper surface is faster than over the lower, resulting in 'thinning' of the air and consequently locally reducing its pressure.

It is the lift force which provides the useful mechanical work for the wind generator.


Bryn Titli Wind Farm


Kirby Moor Wind Farm

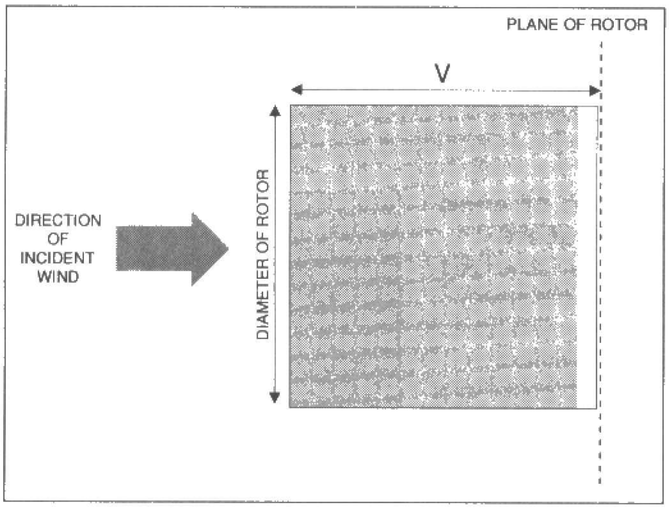


Fig. 7: Incident air on horizontal wind rotor: a fraction of the kinetic energy of air (velocity V) incident on the rotor area is transformed to useful mechanical work

Figure 7 indicates how the zones of air passing across the rotor area for a horizontal machine are influenced. In one second, the kinetic energy of air incident on the rotor area is given by:-

$KE = 0.5 \times \text{mass of air} \times \text{velocity2}$ $KE = 0.5 \times (3.142 \times \text{radius2} \times \text{density} \times \text{velocity}) \times \text{velocity2} = 0.5 \times 3.142 \times \text{radius2} \times \text{density} \times \text{velocity3}$

There is a theoretical limit of around 0.59, however, to the fraction of energy that can be removed from the moving column of air. The efficiency term is typically described as Cp - the power efficiency of the rotor. The delivered power, Pdel, can then be expressed as:-

$Pdel = Cp \times 0.5 \times 3.142 \times \text{radius2x density} \times \text{velocity3}$

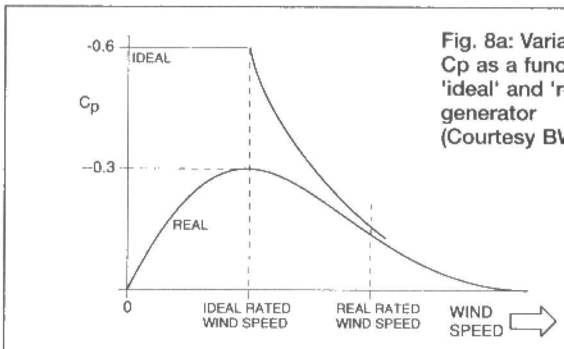


Fig. 8a: Variation of Cp as a function of 'ideal' and 'real' generator (Courtesy BWEA)

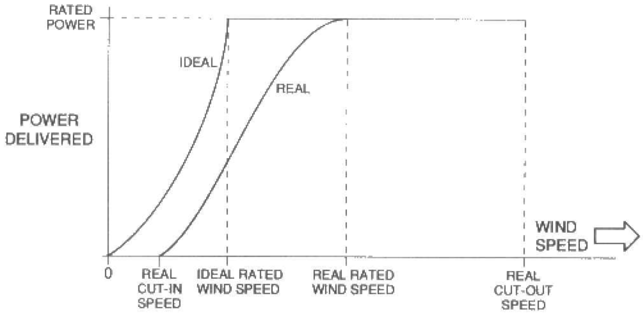
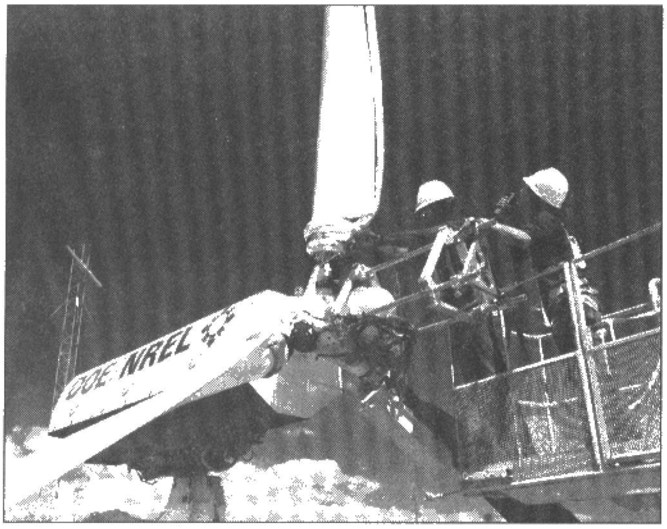


Fig. 8b: Corresponding power generation performance of 'ideal' and 'real' generators.(Courtesy BWEA)

The design of the generator requires that the value of Cp decreases at progressively high wind speeds in order to limit power generation within safe limits. In order to achieve this, the value of Cp will typically vary as indicated in figure 8a for the 'real' turbine. The corresponding power delivered is indicated in figure 8b. This tends to provide for reasonable efficiency at low and medium winds but to provide adequate safety at high wind velocity. The 'correct' wind generator for a specific location is very much determined by the prevailing wind patterns. Planners now can model energy generation for different generators as a function of locality wind data in order to optimise choice of generator. A key part of advanced rotor design is to be able to vary the rotor profile in order to optimise Cp for any wind speed. Two main options are utilised. The simplest is to design the blade so that even in the strongest winds Cp is never great enough to overdrive the generator. This configuration is termed 'stall regulated'. In a 'pitch regulated' system, the length of the rotor may alter or the pitch angle along the rotor be altered. Such rotors are more complex to design and, hence, are more expensive. The benefit of such systems is that they generate more electricity than stall regulated systems.

There is also the disadvantage that pitch regulated systems tend to be subjected to greater variations in drive force due to gusting winds. Wind generators tend to operate at a fixed rotational speed so that power can be generated at a synchronised mains frequency. Some gear systems can provide an option for choice of fast/slow rotational speeds in order to optimise efficiency of power generation with different wind speeds.

Figure 9 outlines the definitions relating to pitch for a horizontal axis wind generator. Alternately, the whole generator can be turned 'out of the wind' to reduce power generation by 'yaw' control. Such 'yaw' control is usually controlled by a wind direction indicator mounted on the rear of the nacelle unit which in turn controls hydraulic systems. Wind generators essentially remove energy from moving columns of air.



The air stream 'down wind' of a wind generator will be moving more slowly than the incident air stream. Some simple calculations, however, on the potential power of the wind yields some staggering results as indicated in table 2 where the kinetic energy of motion of air of different volumes moving at 5 m/s is estimated. A key figure used in this calculation is the density of air as 1.2 kg/m3.

Volume	KineticEnergy (Joules)
1 m3	75
10 m3	750
1km3	1.5 x 1010
landmass of UK x 100 m high	3.75 x 10 14

Table 2: Indication of kinetic energy in moving volumes of air at 5 metres per second: density of air taken as 1.2 kg/m3)

It is an astonishing fact that the kinetic energy of motion of a cubic km of air moving at 5 m/s is the same order of magnitude as that which the UK electricity grid generates in one second - based on a total grid capacity of 20,000 MW.

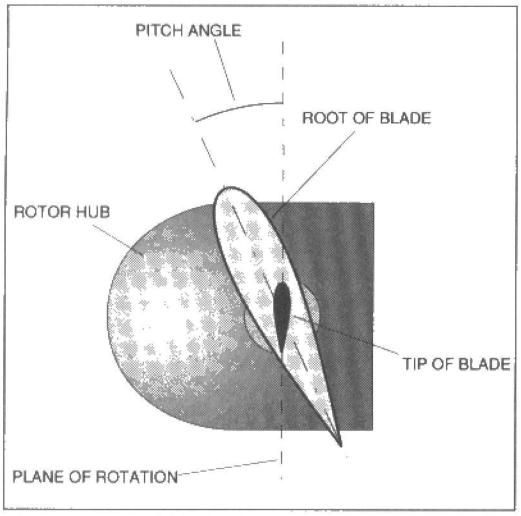


Fig. 9: Definitions relating to pitch angle of rotor to plane of rotation of rotor. The 'hub' relates to the rotor close to its centre and the 'tip' to furthermost extent of the rotor (Courtesy BWEA)

For comparative purposes this is also the same order of magnitude as the peak solar power developed from a square km of photovoltaic collectors.

Wind generator characteristics

The Directory of Wind Turbine Manufacturers and U.K. Agents which is published by the National Wind Turbine Centre indicates the wide range of models being supplied to the UK market. While studies have been made of vertical axis types, the commercial market is exclusively of conventional horizontal axis types. Details of some Nordex models are included to give some typical facts and figures about existing production models.

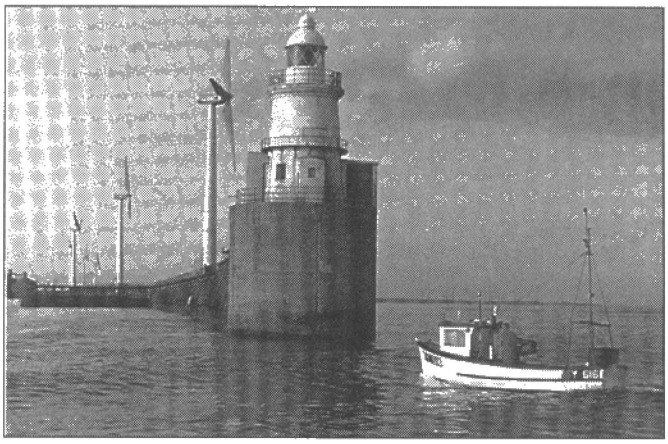
Nordex wind generators

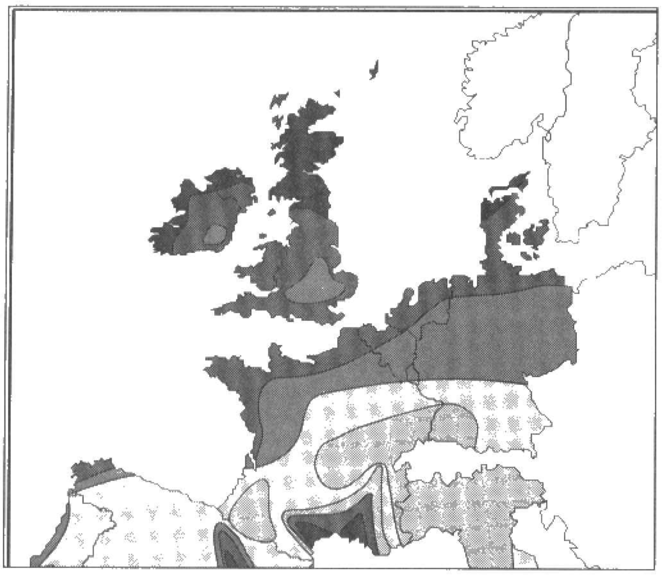
There are a great many types of models of wind generator in production. Table 3 outlines some facts and figures about large wind generators produced by Nordex in Denmark. The pace of demand is such that companies can now develop new designs based on revenues of sale of existing models.

	Nordex N43/600	Nordex N54/1000
Rotor diameter	43m	54m
Swept Area	1452m2	2290m2
Cut in speed	3-4 m/s	3-4 m/s
Cut out speed	25m/s	25 m/s
Survival Wind speed	55 m/s	55 m/s
Rotational Speed	17.9/26.9 RPM	22/16 RPM
Nominal Output	590 kW	993.1 kW
Nominal wind speed	13 m/s	16 m/s
Gear ratio	1:55.8	1:45
Noise at nacelle	99.5 dB	-
Noise at 200 m	43.5 dB	-
Tower Height	50 m	60 m
Total weight	91.4 tonnes	166 tonnes
Yaw rate	0.82 deg. sec	0.4 deg. sec

Table 3: Design/performance characteristics of larger Nordex wind generators.

The Nordex N43/600 utilises stall regulation of its rotors compared with pitch regulation. This results in reduced dynamic loads on the rotor system due to gusting winds. The rotors are manufactured from fibreglass reinforced polyester. Blade tips, some 2.7 metres long at the end of each rotor, act as the principal means of braking and can be angled up to 85 degrees





Assessment of the European wind resource based on geographical. The UK has over 50% of realisable European wind resource (reproduced from the European Wind Atlas:Troen and Peterson 1989)

to the pitch of main rotor tip. A separate brake system on the low speed side of the main gear system acts as a 'parking' brake to prevent the rotors turning during maintenance. A separate 'emergency' brake system can also be employed if other braking systems suffer failure. The process of braking the generator places large stresses on the gear/generator assembly and such generators should be shut down, if possible, as gently as possible using the brake rotor. Other Danish companies, Nordtank Energy Systems and Vestas, are also currently developing a 1.5 MW rated systems. Table 4 indicates the rated power output of the Nordex N29, N43 and N54 as a function of wind speed. With increasing wind speed, these systems increase output up to a maximum rated output power. For winds beyond this level, the air brakes progressively come into play until the cut out wind speed is reached and the generator is shut down. This aspect of shut down is to protect the rotor/gear/generator system from excessive forces and mechanical energy transformation.

wind speed	rated output kW	Power kW	m/s kW
	N29/250	N43/600 N	54/1000
4	12.0	12	15.5
5	24.0	40	50.2
6	35.0	70	105.7
7	58.0	115	191.0
8	95.0	185	305.1
9	128.0	270	418.1
10	161.0	360	542.2
12	213.0	530	726.7
14	234.0	630	899.2
16	254.0	635	993.1
18	265.0	625	1033.5
20	267.0	590	1021.0

Table 4: Rated output power of Nordex N29, N43 and N54 systems as a function of wind speed.

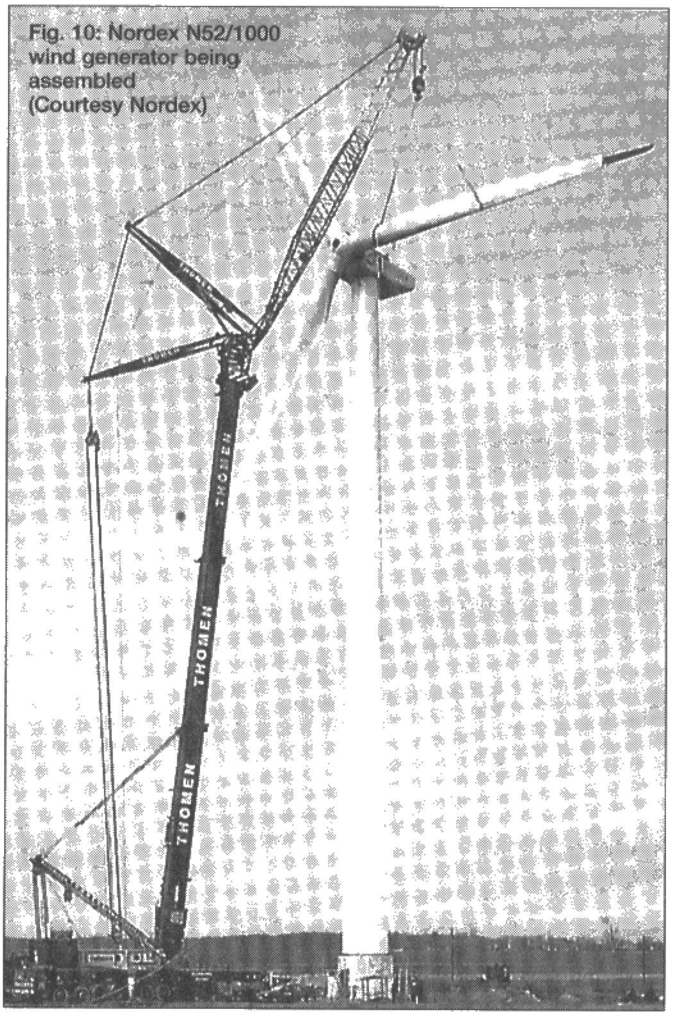


Fig. 10: Nordex N52/1000 wind generator being assembled (Courtesy Nordex)

Figure 10 shows the assembly of a Nordex N52/1000 wind generator - one of the largest wind turbines currently in production. As an indication of the demand for its products, Nordex has doubled its sales each year for the past four years. Figure 11 shows a Nordex N43/600 towering above a landscape of trees.

Measuring the wind

Wind farms represent a significant investment and it is natural that investors investigate thoroughly potential wind farm sites in order to ensure their success. Since the developed power varies as the cube of the wind speed, it is crucial to optimise the chosen site to be as windy as possible. A wind site with an average wind speed of 5 m/s will, in theory, give twice as much power as a wind site of 4 m/s. Wind profiles vary considerably with location and with height.

A full evaluation of wind performance may only be determined over periods of several years. One alternative approach is to measure a new site for between 6 and 12 months and relate these measurements to a nearby site with a long term record extending over several years. This method is known as MCP - Measure, Correlate, Predict. Meteorological Office data from a selected network of 48 stations has been used to develop a wind resource model - NOABL which calculates wind speeds in square km extents. Combining this data with distribution of land types within the UK and excluding National Parks, Areas of Outstanding Natural Beauty and Sites of Special Scientific Interest, it is estimated that wind power could produce more than the current electricity supply - 300 TW per year.

> Assessing, however, aspects of variations in demand and variability of wind supply, it is reasonable with current storage technology to limit this value to 20% of current electricity supply.

Wind resources[1] at 50 metres above ground level for 5 different topographic conditions										
	Sheltered terrain[2]		Open plain[3]		At sea coast[4]		Open sea[5]		Hills and ridges[6]	
	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}
█	> 6.0	> 250	> 7.5	> 500	> 8.5	> 700	> 9.0	> 800	> 11.5	> 1800
▓	5.0 - 6.0	150 - 250	6.5 - 7.5	300 - 500	7.0 - 8.5	400 - 700	8.0 - 9.0	600 - 800	10.0 - 11.5	1200 - 1800
▒	4.4 - 5.0	100 - 150	5.5 - 6.5	200- 300	6.0 - 7.0	250- 400	7.0 - 8.0	400- 600	8.5 - 10.0	700- 1200
░	3.5 - 4.5	50 - 100	4.5 - 5.5	100 - 200	5.0 - 6.0	150 - 250	5.5 - 7.0	200 - 400	7.0 - 8.5	400 - 700
·	< 3.5	< 50	< 4.5	< 100	< 5.0	< 150	< 5.5	< 200	< 7.0	< 400

Estimated energy production over specific land features for zones outlined in 12a (reproduced from the European Wind Atlas: Troen and Peterson 1989)

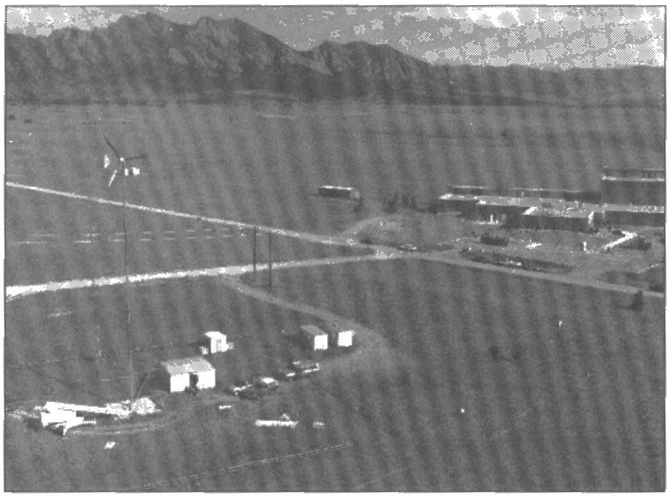
European wind map

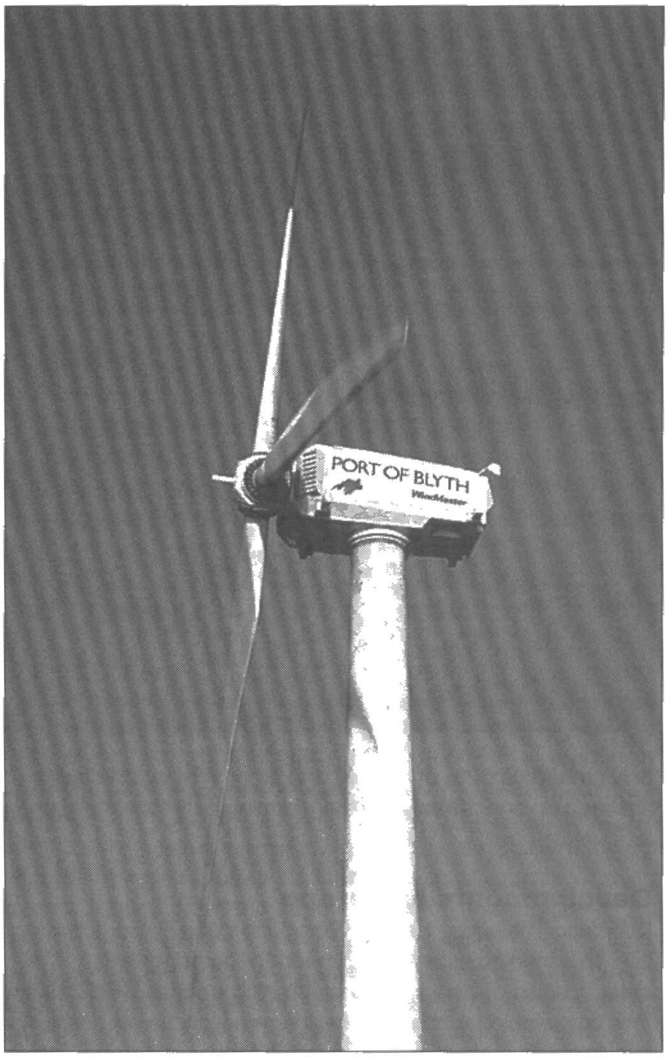
Figure 12a indicates an assessment of the European wind resource based on geographical areas and linked to table figure 12b, which identifies separate specifications for sheltered, open plain, sea coast, open sea and hills. This present map predates the unification of Germany. This again emphasises the importance of adequate wind surveys to be undertaken to optimise locations and match these against wind generator performance. From this distribution it is easy to see why Denmark, Germany, the UK, Ireland, Spain, the Netherlands and Greece are proceeding with wind energy programmes. Spain would seem to be well placed with both solar and wind energy. There is a concentration of high winds south of the Pyrenees and also in the North West corner. To provide some perspective, the UK has over 50% of the realisable wind power of the whole of Europe.

Environmental impact

Noise: The noise from wind generators can be identified as being derived from the aero- dynamic noise of the rotors moving through air and the noise generated by mechanical elements such as the transmission and gearbox of the generator system. By careful design of wind generator, however, manufacturers have been able to reduce both contributions to noise. The noise criteria is being taken very seriously by manufacturers since aspects of noise pollution may be of critical importance in obtaining planning permission for wind farm sites. Larger turbines are likely, however, to broadcast noise over larger geographical areas. Off-shore wind sites, however, will essentially be able to be operated without serious consideration of noise pollution.

Visual Impact: It is the assessment of visual impact which has principally led to the refusal of planning permission at various locations in the UK. This aspect can be broken down to the general location of the wind farm, the size of the generators and the specific location of generators within the wind farm area. As there is a drive towards larger generators with taller towers and larger rotors, so there is the potential for more problems related to visual impact of schemes. Off-shore wind farms may therefore be a serious contender for future major schemes.

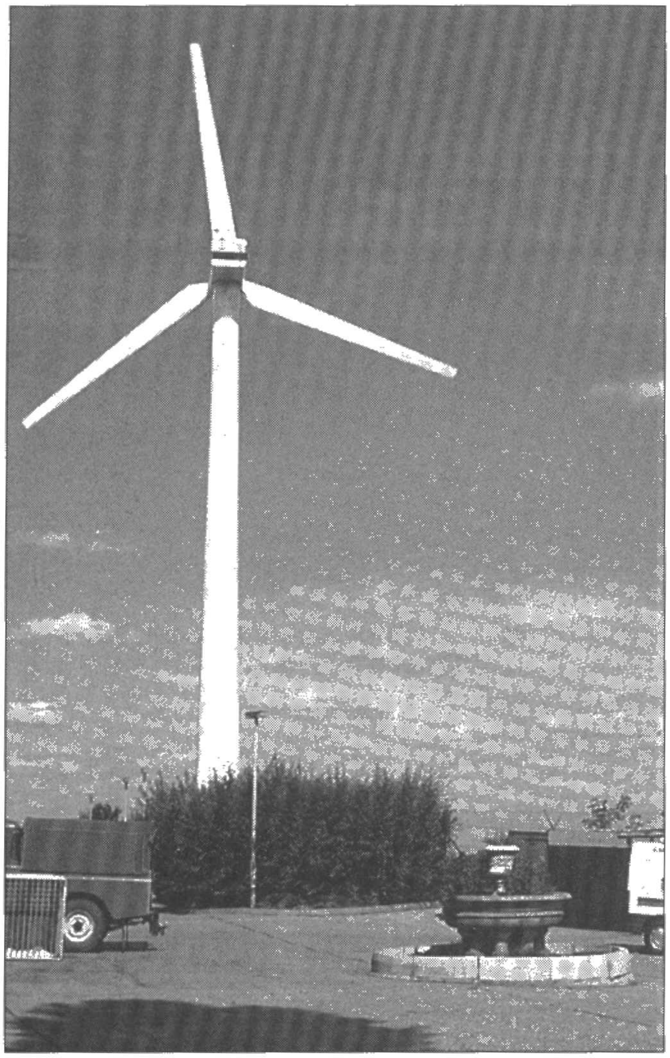




Wildlife: Experience in California has indicated that some wind power sites can adversely affect bird populations. This indicates, therefore, that close liaison is required between Bird Protection agencies and agencies planning wind power installations in order to minimise any possible impact on the bird population. Experience of operating windmills in Northern Europe, however, has indicated little, if any, problem.

Land area

In terms of wind power, the fact that present wind turbines are mounted on towers reduces significantly the amount of land actually taken out of use due to access roads and tower installations. It is estimated that a wind generating capacity of 1% of current UK electricity requirement would utilise around 200 km2 of area - around 0.1% of total UK land area. If the area occupied by the turbines is considered, this equates to



only around 0.002% of the UK land area. Where wind farms are sited on agricultural land then farming activity is more or less undisturbed.

Developments in Europe

Denmark: The success of the European Wind Power industry has, to a marked extent, relied upon the foresight and determination of Denmark in establishing a viable wind industry. This has enabled wind power programmes to be successfully implemented at many locations around the world using Danish technology and provided an industry in Denmark which now employs as many people as its fishing industry. One of the key manufacturers of wind turbines, Vestas, sold 184 turbines with a capacity of around 150 MW during 1984. In looking at the employment pattern as a whole, it is estimated that in 1995 with a manufacture of 540 MW of capacity both in Denmark and licensed assembly/ manufacture abroad of Danish designs, at a global level, employment was provided to 12,000 with around 7,800 being employed in Denmark. By the end of 1994, Denmark had an installed wind power capacity of around 540 MW. It was in this year, in fact, that Germany robustly overtook Denmark's installed wind power capacity.

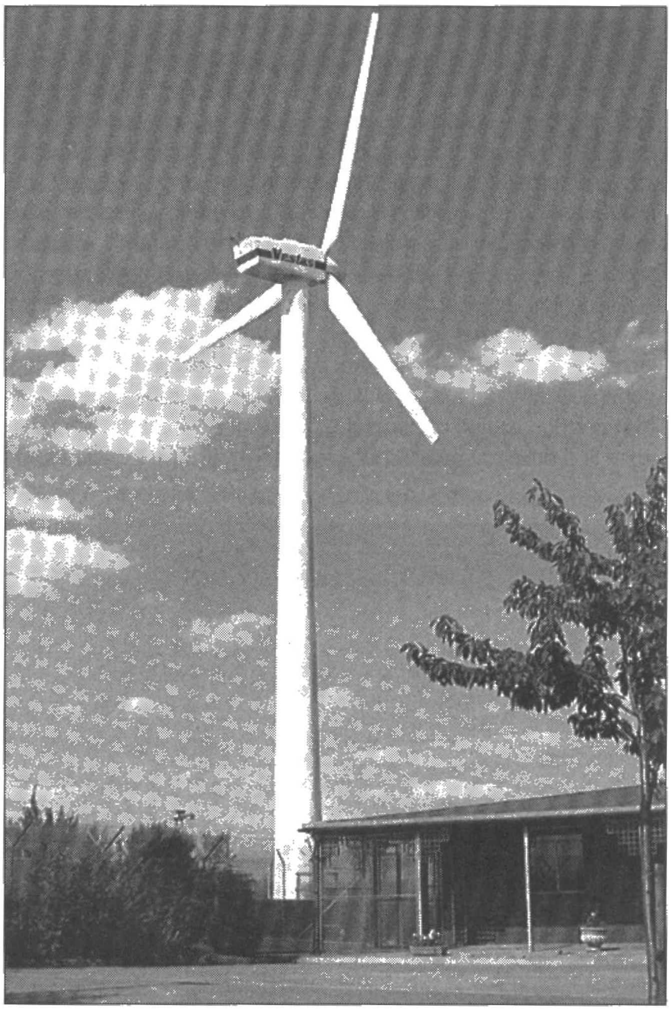
Germany: By the end of 1994, Germany had an installed wind capacity of 632 MW - a staggering 94% increase on the previous year. During 1995 the Bonn government announced an increased allocation of funds to renewable energies in the form of a four-year $68m programme. This will be a mix of solar, heat pump, biomass and wind power capacity with the emphasis on promoting wind power inland as well as on coastal areas. On account of the large fossil and nuclear generating capacity of Germany, however, the percentage of renewable energy is only expected to rise from 4.7% in 1994 to 6% by 2005 with the planned wind capacity of 2700 MW by 2000.

Netherlands: It was in 1993 that the UK overtook the Netherlands in installed wind power capacity. There has, however, been a recent initiative of the launch of a National Bureau for Wind Energy to try and achieve a target capacity of 1000 MW of capacity by the year 2000. The southern Dutch energy company, PNEM, is investigating a 'green' customer option for buying 'green' power from renewable sources. This would involve payment of an additional premium for the supply of such energy.

This is in some ways quite different from the UK option of charging customers a relatively large amount to subsidise the UK nuclear industry. Such 'green' initiatives, however, must be seen as a means to accelerate the uptake of 'green' energy anywhere. Ireland: During 1995 Ireland announced its Alternate Energy Requirement programme. Out of a total of 111 MW, a wind capacity of 73 MW is planned to be operational by 1997. The planned policy of deregulation of the electricity industry in Ireland has stalled, following observation of rapidly increasing power costs in the UK following the deregulation of the power industry.

Wind power in the UK
Non-fossil fuel obligations

Under the Electricity Act (1989), the so called Non-Fossil Fuel Obligation was established. This provided confirmed prices for supply of energy from non-fossil sources. The majority of



Cemmaes Wind Farm, Mid Wales - developed by National Wind Power Ltd.
Courtesy National Wind Power Ltd)

funding supports the Nuclear Industry with the remainder supporting renewable sources such as wind energy. Figure 13 indicates the status of NFFO Wind Projects at December 1994. In determining such projects, applications are made by interested parties for specific projects. These are then awarded based on general assessments of site suitability and viability. Then follows submission of schemes to local authorities who reserve the right to refuse planning permission. Based on NFF0 1 & 2, approximately 20% of schemes are refused initially. During late 1994 NFFO 3 was announced for England and Wales and a separate Scottish Renewable Order - SNO 1 - was established. The total installed wind generation capacity awarded was 491 MW spread over 67 sites. This new order incorporates a planning/construction phase of five years and an guaranteed revenue period of 15 years.

This allows more time for appropriate planning and development of sites than previous NFFO schemes.

Rutherford Appleton Laboratory

As part of the Energy Research Group at Rutherford Appleton Laboratory (RAL), the focus of attention is in studying aspects of wind turbines with a view towards designing more efficient systems. A main area of research has been to monitor pressure profiles across rotor blades using a 45 kW rated Windharvester system on the Wind Test Site at RAL. Projects are also underway to investigate energy storage/recovery systems based on a flywheel technology. The keynote of work at RAL is cooperation with UK and European Universities and wind turbine manufacturers. One project of interest relates to the cogeneration of hydrogen and electricity using wind power.

The National Wind Turbine Centre

The National Engineering Laboratories (NEL) at East Kilbride, after having provided engineering support to the conventional engineering base within Scotland, are now providing support for renewable energy technology.

The National Wind Turbine Centre at East Kilbride, some 15 miles south of Glasgow, has a wind turbine test site at Myres Hill and a unique full-scale structural testing laboratory. While providing expertise on the basic engineering and design aspects of wind turbines, the group is also able to provide a broad base of services ranging from wind surveys to planning, developing and commissioning of wind farms. The centre is also playing an active part in performance verification and development of international standards for wind turbines.

	Project Status	No. of Projects	No. of Turbines	Total Rated Capacity (MW)
NFFO-1	Generating	8 (5)	76 (73)	27,715 (26,490
	Withdrawing	1 (0)	4 (0)	1,180 (0)
	Total	**9 (5)**	**80 (73)**	**28,895 (26,400)**
NFFO-2	Generating	23 (16)	330 (322)	112,310 (99,075)
	Under construction	4 (4)	56 (56)	13,500 (13,500)
	Approved	2 (2)	21 (21)	4,935 (4,935)
	Refused	14 (11)	143 (140)	42,050 (41,250)
	Not submitted	6 (6)	102 (102)	24,200 (24,200)
	Total	**49 (41)**	**652 (643)**	**196,995 (183,020)**
NFFO-1 & NFFO-2	Generating	31 (21)	406 (395)	140,025 (125,565)
	Under construction	4 (4)	56 (56)	13,500 (13,500)
	Approved	2 (2)	21 (21)	4,935 (23,300)
	Refused	14 (11)	143 (140)	42,050 (41,250)
	Not submitted	6 (6)	102 (102)	24,200 (24,200)
	Withdrawn	1 (0)	4 (0)	1,1809 (0)
	Total	**58 (46)**	**732 (716)**	**225,890 (209,420)**

Fig. 13: Status of NFFO-1 and NFFO-2 at end of 1994.

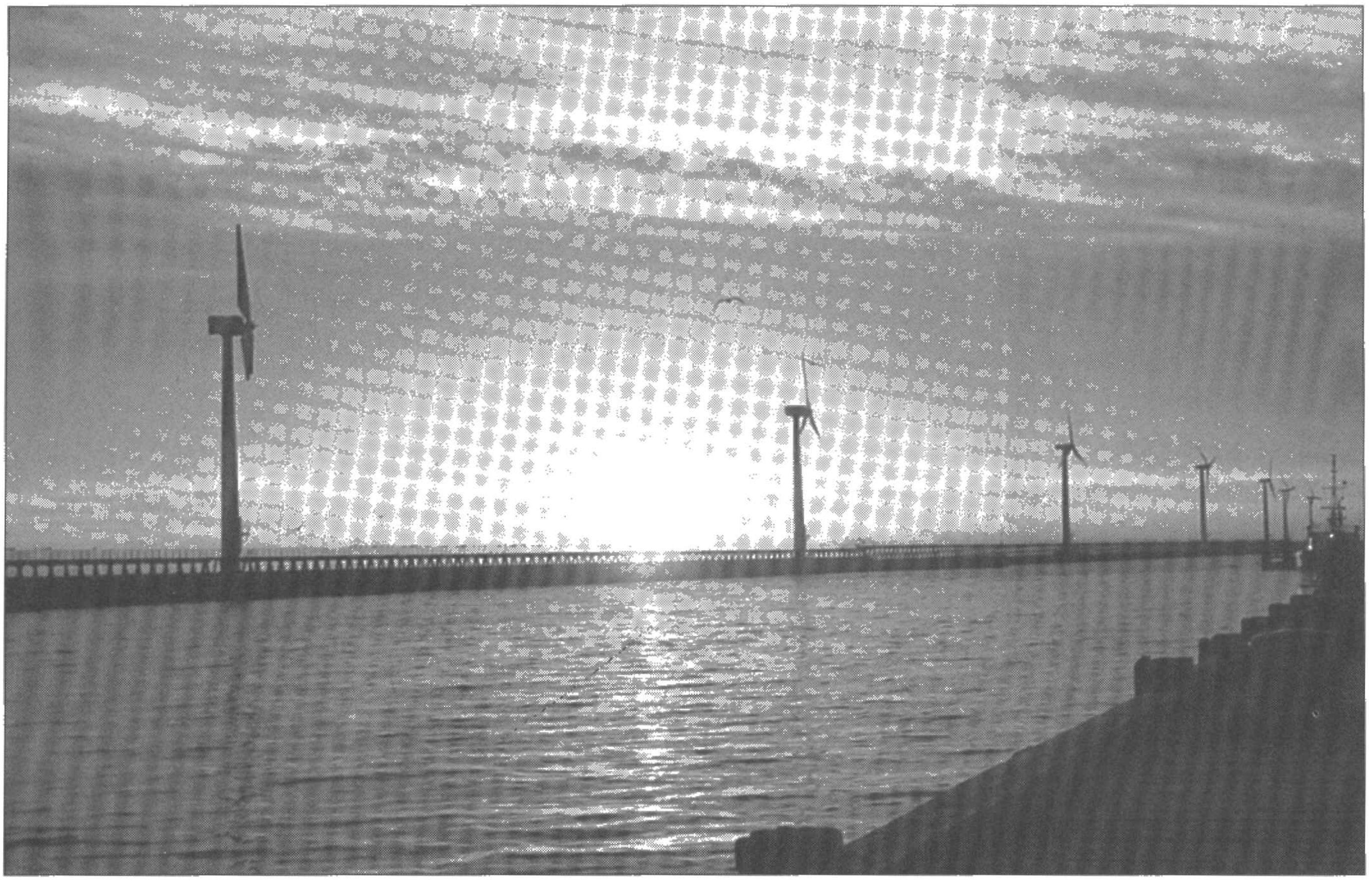


Fig. 15: Blythe Harbour Wind Farm. (Courtesy ETSU)

Off-shore wind energy

While development of land-based wind farms offers the lowest cost proposition, studies have also been undertaken of off-shore wind energy. This is principally taken to relate to utilisation of sea depths of less than 30 m. Initial experience with Danish and Swedish prototypes has indicated that capital outlay and subsequent maintenance costs would increase by between 50% and 100% - resulting in the supplied electricity being at least 30% higher than current land based systems. The UK government has commissioned several studies of large-scale off-shore wind farms utilising large generators of rated capacity 6 MW. A wind farm of 330 generators with a rated capacity of 1980 MW would cost in the region of £2,640 million and would cost around £58.00 million to operate per year. Such projects, however, would likely be implemented over time scales of between 10 and 20 years. The existing high level of expertise of the UK in off-shore oil installations could be usefully translated into this engineering sector at around the time the finite fossil fuel reserves in the North Sea begin to dwindle.

Wind farms in the UK

The wind generating capacity of the UK has steadily increased under successive NFFO orders. The status of systems at the end of December 1994 was a generating capacity of 125 MW. This had increased to 24 wind farms, 431 turbines and 150 MW of capacity by June of 1995. With development of sites under NFFO-3 it is anticipated that capacity will be in excess of 200 MW during 1996. The first wind farm in Wales to be commissioned was that at Cemmaes - not far from the Centre for Alternative Energy at Machynlleth in Mid Wales. This grouping of 24 Vestas 400 kW rated generators developed by National Wind Power Ltd has been extensively studied for environmental impact and social impact and is shown in figure 14. The wind farm at Blythe Harbour on the North East coast is shown in figure 15. This wind farm of 9 units of HMZ turbines each of capacity 300 kW utilises effect of higher wind speeds along coasts to improve economics of generation.

Developments in the USA

It is interesting to note that free enterprise alone has not been enough to kick start wind power technology in the USA. With until recently the majority of wind generators being of European origin, this acted as a stimulus for initiating a home-grown wind power research programme funded by federal funds to develop new generations of cheaper and more efficient wind generators. A key factor is the design of the rotors used - typically of three bladed type. Work at the National Renewable Energy Laboratory (NREL) has produced a rotor design which can improve energy capture by between 20% and 70% depending on wind speed and the degree of blade contamination from dirt and insects. Rotors with designs based on aerofoils for aircraft tend to suffer significant degradation of performance. Specific system designs tend also to improve the efficiency of the gearbox/transmission system. Also, the lighter the structure of the active components (housing/blades etc), the less material is required for the supporting tower.

The trend will be to use lighter/stronger materials in order to reduce the materials cost of systems. It is anticipated that rated power outputs in this federal programme will increase from between 300 to 500 kW to between 500 to 1000 kW. Specific improvements in output and efficiency are expected to arise from the use of advanced generators which dispense with gearbox stages, advanced control systems using extensive computer monitoring of wind profiles with interaction to generator/rotor configuration and continued development of rotor materials. At Sandia Laboratories at Albuquerque developments in wind energy are primarily directed towards refining models of reliability for mechanical components of wind generators. This primarily relates, for example, to optimisation of rotor elements. Often, however, reliability modelling is related to specific knowledge of the fatigue strength of materials and there is encouragement in maximising information on such parameters. The fragmentation of energy policy down to state level has in many ways added complications to renewable energy policy in the USA. As new directives on energy policy begin to be implemented, it is too early to determine how much encouragement will be given to renewables in general and wind power as a specific form of renewable energy. According to Henry Dodd at Sandia, predictions of 10,000 MW of installed capacity by the year 2000 are now looking decidedly optimistic. Development work of a more practical type is undertaken at the National Renewable Energy Laboratory (NREL) where specific wind turbines are assessed for output power and reliability. The USA is, however, working closely with Europe in the development of standards for specifying and measuring wind generator performance. According to Sue Hawk at NREL, 'harmonisation' is the key word. This should make it simpler to characterise wind generators and compare operating performance. At this time, however, Europe has moved ahead of the USA in installed capacity due to the upsurge of Research and Development work in Europe working through to wind generators of improved efficiency. It is apparent, however, that Europe is acting primarily out of environmental impact of fossil fuels while in the USA it is the financial cost/benefit that appears to be the prime directive.

In the developing world

As the developed world examines its conscience and looks to try and stem the increase in its own carbon dioxide emissions, the greater threat to the future lies in how the developing world seeks to increase its energy provision. China, for example, has vast reserves of coal which if consumed rapidly would certainly act to destabilise the world climate. There are some hopeful signs. India is especially receptive to wind energy and plans to have 1000 MW of capacity by the year 2000. In China, various schemes are being implemented. The impact of such systems, however, will be determined by the framework provided for their use by national and local government.

Patterns of investment

The world's present energy mix is the result of a vast investment in conventional energy sources. While the rate at which wind power schemes can be brought on line is limited by other factors apart from finance - eg wind surveys, project planning and grid connection - there is no doubt that the rate at which capacity can be increased could be increased by additional investment in wind farms. Table 5 indicates an approximate relationship of invested sum against nominal rated wind capacity - using data for typical individual wind generators of 0.5 MW capacity. It is likely that the cost per megawatt will be less for larger generators of between 1.0 MW and 1.5 MW.

Amount Invested	Nominal Rated Wind Capacity
£500,000	0.5 MW
£5M	5MW
£50M	50 MW
£500M	500 MW
£5000M	5000 MW

Table 5: Relationship between sum invested and nominal rated wind capacity.

Summary

In an age where investment in energy is in the independent sector, wind power also provides some excellent 'blue chip' financial numbers. The power generating utilities, however, should not be backward in tapping into green consumerism by offering energy which is environmentally more acceptable. Perhaps on all our fossil fuel bills we should be reminded of how much carbon dioxide we have paid to be released into the atmosphere. Purely for my domestic electricity I estimate this as 5 tonnes. In the process of investment in renewable energy, it is clear that a spread of resources is required. While wind energy is appropriate on a windswept hillside in Wales, photovoltaic panels are appropriate on an office roof in central London. It seems, however, that a major source of renewable energy for the UK is 'blowing in the wind.......'

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Best Available Energy Technologies for our Environment: THERMIE Directorate, Brussels. (see points of contact)

NEW REVIEW, The Magazine of New and Renewable Energy, published by Department of Trade and Industry (contact ETSU, Harwell)

WIND DIRECTIONS, Quarterly newsletter of the British and European Wind Energy Association (contact British Wind Energy Association)

Renewable Energy General Literature List:WIND - A comprehensive list of general literature related to wind energy. WNG Issue 4, ETSU (see points of contact)

Renewable Energy Reports List:WIND - A comprehensive list of technical contractors' reports and related reports on wind energy. WNR Issue 4, ETSU (see points of contact)

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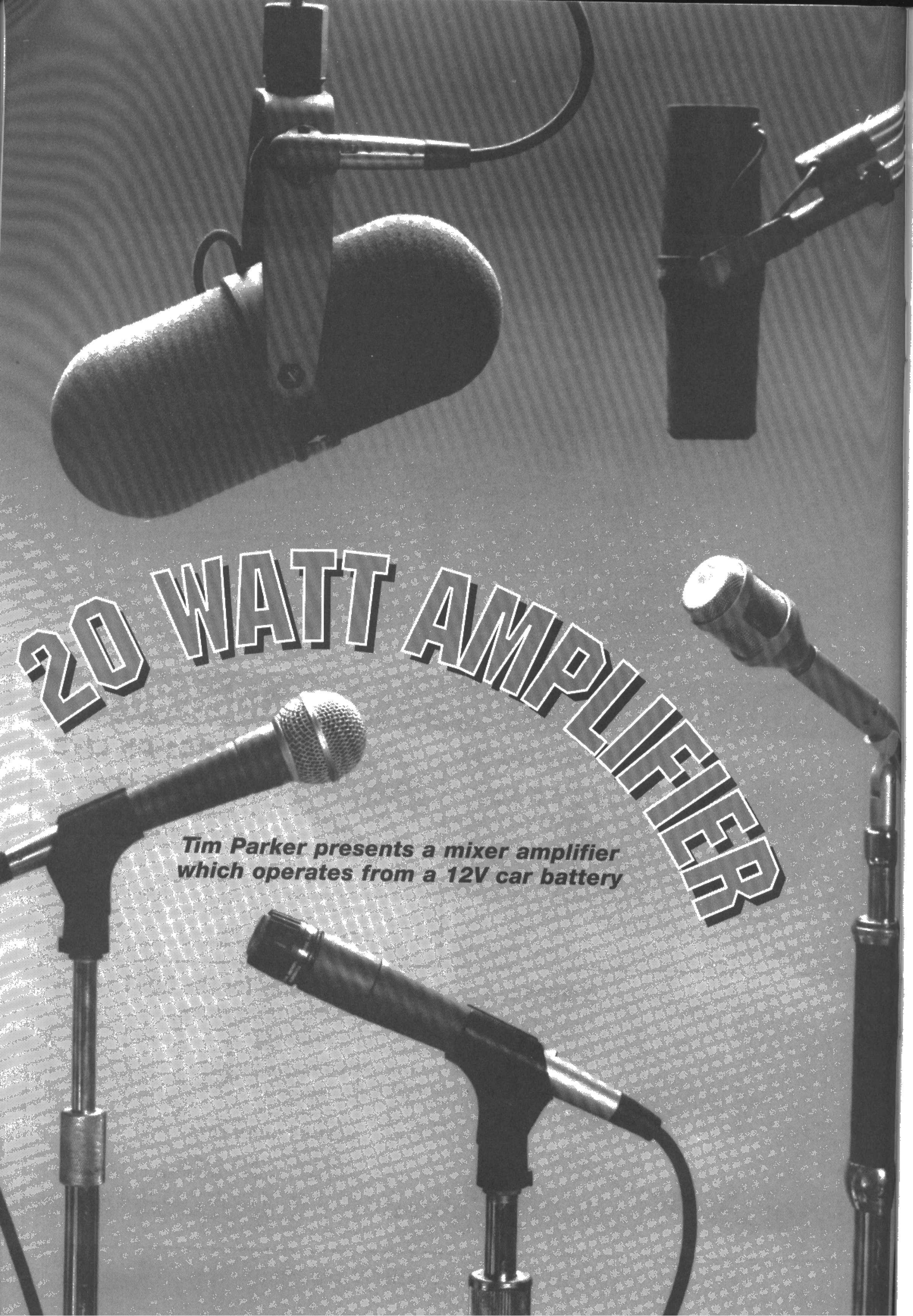
20 WATT AMPLIFIER

Tim Parker presents a mixer amplifier which operates from a 12V car battery



People who have the task of addressing small outside gatherings (fetes, sports events, market stalls etc.) will be fully aware of the problems encountered when trying to make themselves heard. High level background noise, a weak voice, or a breeze blowing in the wrong direction (head-on) to name but a few. The project presented here may help to overcome some of these problems. Obviously it won't change the direction of the wind, but it will allow the sound to emanate from a better vantage point by re-positioning the loudspeaker(s). The low voltage operation of the mixer amplifier also makes it a lot safer in operation than having to have trailing mains cables and extension leads across what could be a public access route. Although designed primarily for external operation from a standard 12 Volt car battery, by using a suitably smoothed and regulated mains power supply capable of delivering an output of 9V - 16V DC at 2A, the mixer amplifier will find many other uses indoors, including guitar practice amplifier, vocals & backing track mixer, keyboard amplifier, or a mini karaoke. With the record/playback facility it could even be used to dub sound effects and voice-over onto video footage. Further, with its ability to amplify audio signals from a wide range of sources, it would not be out of place in the electronics workshop, as a bench amplifier or signal tracer.

Circuit description

The complete circuit diagram for the 20 Watt mixer amplifier is shown in figure II and comprises six basic sections as follows: low impedance microphone preamplifier, microphone tone control, line level preamplifier, summing mixer, power amplifier and supply rail splitter.

Microphone preamplifier

Low (600ohm) impedance dynamic microphones produce only a very small output signal, sometimes as low as 15mV under normal sound pressure level conditions, and so require a large amount of amplification in order to give a usable signal. IC1 is a dual operational amplifier and is used to perform this task. ICla is configured as a low gain input stage, with an impedance set to closely match that of the microphone itself (ie. approximately 600ohm). IClb provides further amplification of up to ten times that of the output from ICla, adjustable via the microphone level control VR2. There are two reasons for using a two-stage preamp rather than one high gain stage. Firstly, the operational amplifier's own input noise is not amplified to an undesirable output level; these ICs are not at there best when operated on the fringes of there full power bandwidth capability. Secondly, the low output impedance of IClb provides a buffer for the following tone control to function correctly. If the wiper of VR2 were taken directly to the tone control, then increasing or decreasing the microphone level would have a significant effect upon operational characteristics of the tone control itself. The output of IClb (pin 7) is coupled via C9 to the three channel active tone control based around IC2b. This provides the microphone input with lift (boost) and cut across the audio spectrum via VR3 (bass), VR4 (middle) and VR5 (treble). Most standard tone controls provide only bass and treble adjustment, but in this application the middle control was considered a must. When using the microphone for vocal pick-up a very large portion of the human voice is contained within this band of frequencies, from about 800Hz to 5KHz. Indeed, of the three controls available, you will find that this middle control has the most prominent effect. The tone control only allows adjustment to signals applied to the microphone input; it has no effect on the signal applied to the music input. This is done purposely to allow the vocals at the final output - be it the loudspeaker or the line output - to be adjusted to a sound similar to any others applied to the music input, which is important if someone is trying to sing along to pre-recorded music/songs. Further, it allows the output to be adjusted to individual speakers' (those persons using the microphone) voices in order to compensate for deficiencies within the surrounding acoustics.

Music input

Although the unit has only a mono function throughout, the music input will accept line level signals from both left and right channels of a stereo signal; these are amplified equally so as not to lose either half on reproduction.

The left and right stereo signals applied to either SK2 or SK3 are summed by R6 and R5 respectively. The values of these two resistors are chosen to match standard line (record/playback) impedances, and also to ensure that no 'merging' of the two channels is caused to the equipment supplying the music source. A variable amount of this signal is then fed to IC2a via the music level control VR1. IC2a adds a small amount of amplification to the signal to compensate for weak input signal levels.

If the music signal is being supplied from (say) a low-cost mono cassette player, the sound quality may be somewhat inferior or 'tinny', since these types of machines don't need a high quality output to drive their usually small internal loudspeakers. For this reason capacitor C9 and resistor R12 are included in the feedback path of IC2a, and serve to add a small amount of bass boost to the original input signal. At frequencies above approximately 1.SKHz the reactance of C9 is quite low at about 5Kohm, so R12 is virtually in parallel with R11, thereby increasing the amount of feedback around IC2a, and so reducing the gain. At lower audio frequencies, particularly in the 1OHz - 100Hz range, the reactance of C9 becomes quite significant, being typically 120Kohm at 60Hz. This reduces the shunting effect of R12 across R11, thereby reducing the amount of feedback, and so increasing the gain of the amplifier at these low frequencies.

This response is similar in operation to the loudness button found on some commercial audio equipment. However, there is a minor drawback with the simplified method employed here, in that there is a slight lowering of the high frequency rolloff point due to the filtering effect of the RC network.

The outputs of IC2 (pins 1 & 7) are then coupled to a summing mixer based around 1C3a. R23 sets the gain of IC3a to unity (in other words 1), and C18 adds a small amount of high frequency feedback. The output at pin 1 of IC3a consists of the preamplified final signal mix ready for power amplification.

This is passed to the master volume control via C20, and to the line socket SK3 via C19, R3 and R4. C19 removes the DC offset voltage present at the output of IC3a, whilst R3 and R4 split the signal into two separate but audibly identical paths for left and right channel outputs. The line socket SK3 therefore provides a record and playback facility for connection to tape or video recorders, with the output level being controlled only by the settings of the microphone and music level controls, and is completely independent of the setting of the master volume control.

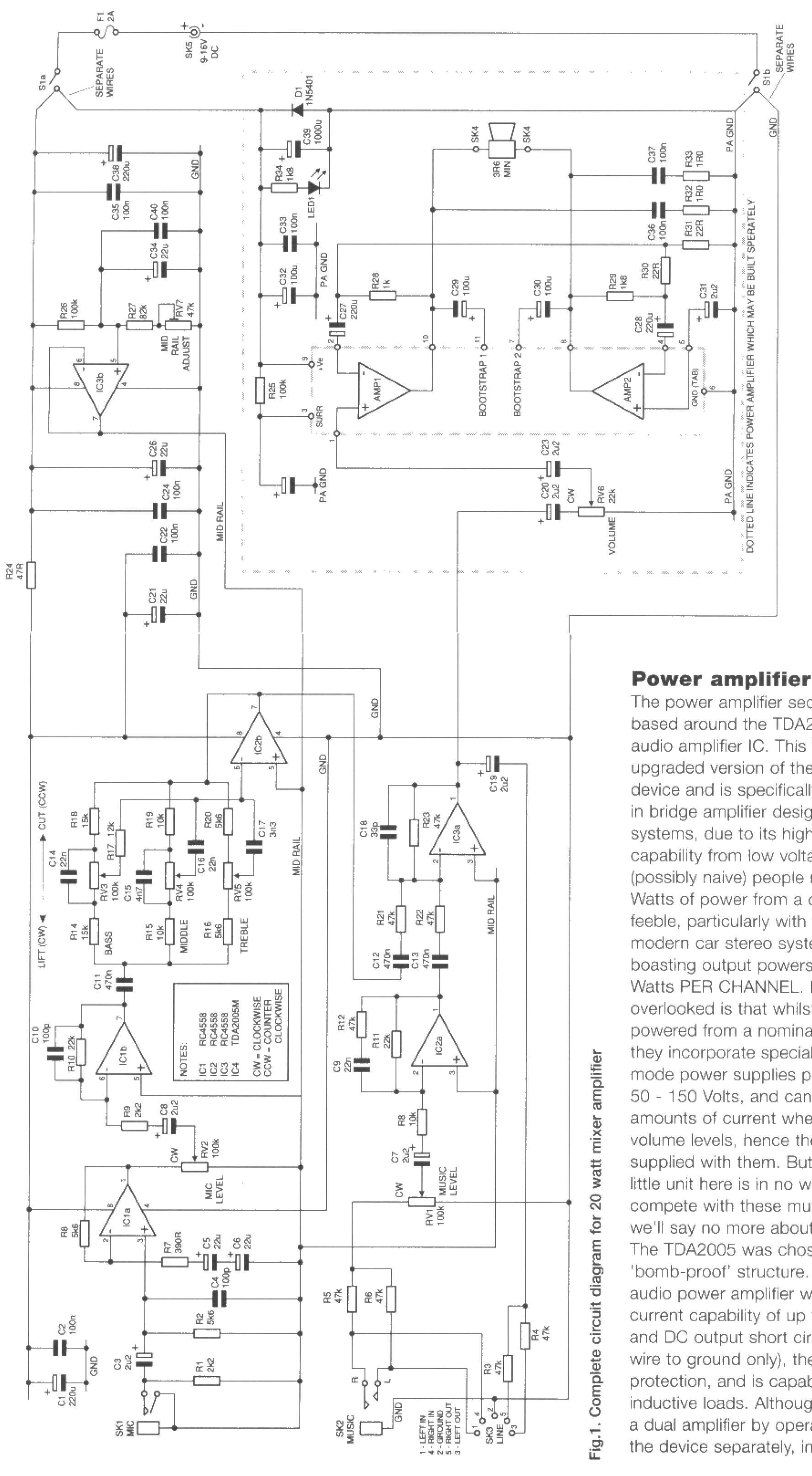


Fig.1. Complete circuit diagram for 20 watt mixer amplifier

Power amplifier

The power amplifier section of the mixer is based around the TDA2005 10W + 10W audio amplifier IC. This is actually an upgraded version of the older TDA2004 device and is specifically intended for use in bridge amplifier designs in car audio systems, due to its high output power capability from low voltage supplies. Some (possibly naive) people might think 20 Watts of power from a car battery is quite feeble, particularly with the availability of modern car stereo systems and amplifiers boasting output powers upwards of 200 Watts PER CHANNEL. But what is often overlooked is that whilst externally they are powered from a nominal 12 Volts, internally they incorporate specialized switched mode power supplies producing possibly 50 - 150 Volts, and can consume vast amounts of current when operated at high volume levels, hence the very thick wiring supplied with them. But since our modest little unit here is in no way intended to compete with these musical monsters, we'll say no more about them.

The TDA2005 was chosen for its almost 'bomb-proof' structure. It's a class B dual audio power amplifier with high output current capability of up to 3.5 Amps, AC and DC output short circuit protection (one wire to ground only), thermal shutdown protection, and is capable of driving very inductive loads. Although it can be used as a dual amplifier by operating each half of the device separately, in this application it

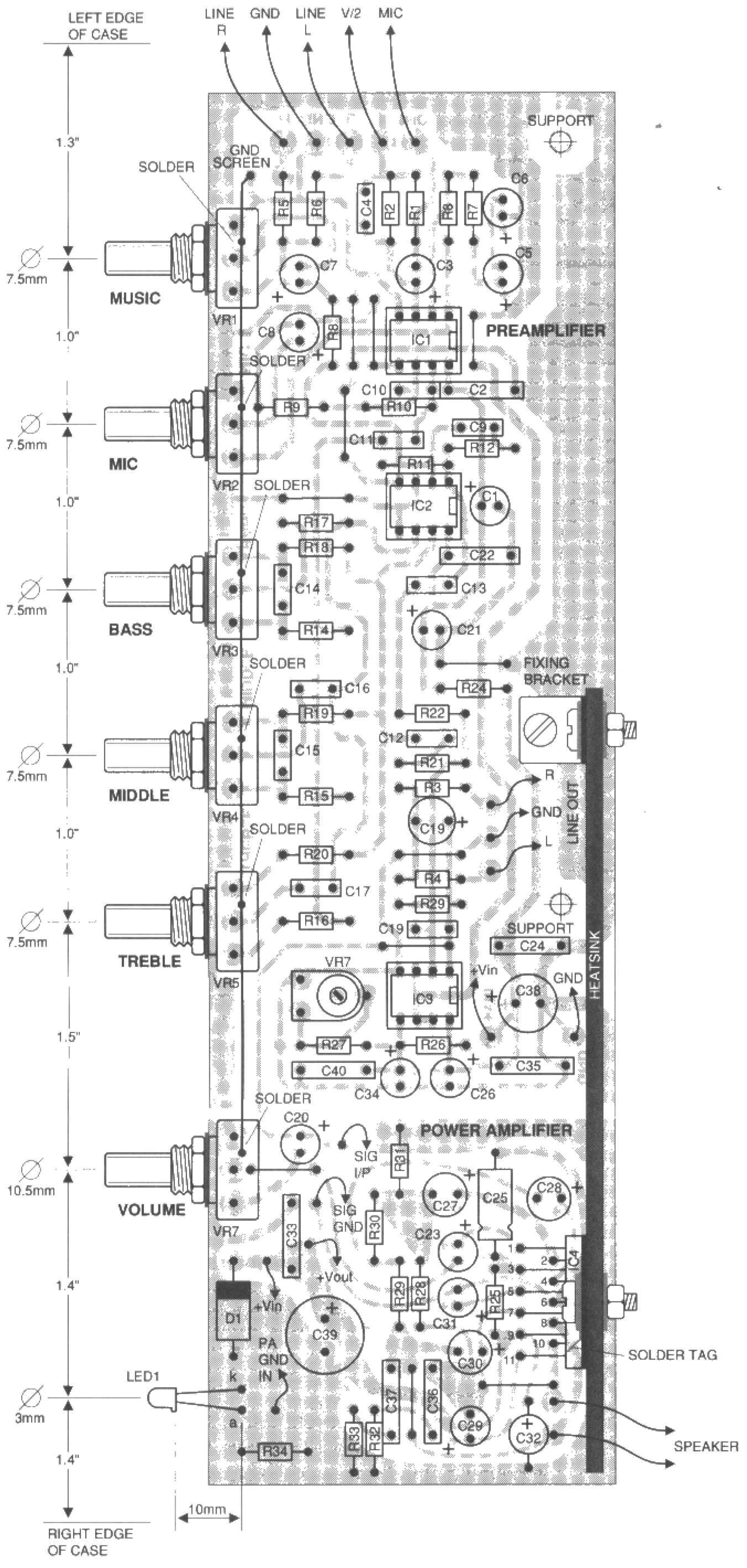


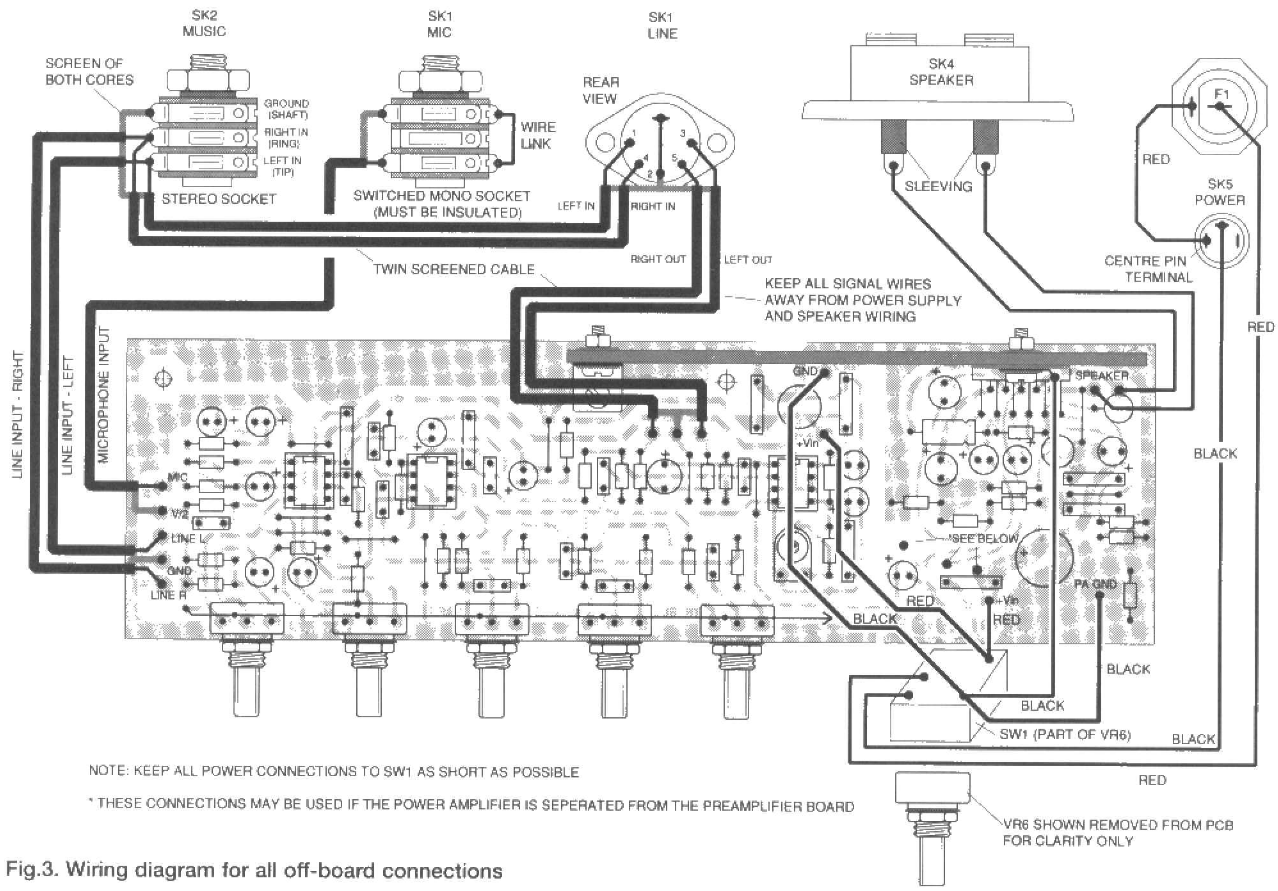
Fig.2. Component layout for mixer amplifier

is configured for operation as a bridge amplifier. With this mode, the current and voltage swings in and around the IC are twice that of a single amplifier, which results in a power output four times greater than that of a single amplifier with the same load (the loudspeaker) connected to the output pins.

Output protection

As with all bridge amplifier designs powered from a single supply, the output terminals of the TDA2005 are both held at half the supply voltage. This eliminates the need for the usually large value DC blocking capacitor in series with the loudspeaker(s). It follows therefore that if one of the loudspeaker wires were to be connected to the physical (chassis) ground, a DC voltage of half supply potential would appear across the loudspeaker(s), and with the high output current capability would theoretically lead to their destruction if they could not handle the resulting high power dissipation. For example, assuming the maximum 16V DC supply voltage and the minimum allowable load of 3.212, each output terminal will be held at 8V DC. With one terminal shorted to ground the current through the load would be 2.5A, yielding a power dissipation of 20W continuously, with a power dissipation in the TDA2005 at about 32W, which is actually above the absolute maximum allowed of 30W. Fortunately though, if this condition arises, not only can the TDA2005 cope with the short circuit, but it also protects the loudspeaker(s) by reducing to a safe level the voltage on the opposite terminal to that which is shorted to ground. What's more, it and can withstand this condition indefinitely with no damage to the device. There will however be quite a large thump from the loudspeakers once the fault condition is removed and the DC output levels are restored to normal.

The components around IC4 set up the gain, bandwidth and stability of the device. C23 couples the signal from the master volume control VR6 to the input of IC4 (pin 1). C25 sets the supply voltage ripple rejection and stabilizes the output symmetry. R25 optimizes the output symmetry to produce the highest possible power output, a value of 120Kohm is the manufacturers' recommendation and



NOTE: KEEP ALL POWER CONNECTIONS TO SW1 AS SHORT AS POSSIBLE

* THESE CONNECTIONS MAY BE USED IF THE POWER AMPLIFIER IS SEPERATED FROM THE PREAMPLIFIER BOARD

Fig.3. Wiring diagram for all off-board connections

should not be adjusted; to do so would reduce the maximum power output. Resistors R28 to R31 set the closed loop gain of the amplifier. These values may be adjusted if instability occurs when the IC is operated at high gain, but with the IC configured as a bridge amplifier the closed loop gain must always be greater than 32dB, and unless you know what you're doing it's best to leave them as they are.

C29 and C30 provide bootstrapping in order to obtain the maximum available output power. Larger values will have little or no beneficial effect, whilst smaller values will result in distortion at low frequencies. C27 and C28 provide feedback and DC decoupling. Increasing these values will also have little or no effect, whilst lower values will result in a higher low frequency rolloff, and so reducing the ICs response to bass frequencies. C36, C37, R32 and R33 provide frequency stability. Altering the values of any of these components will almost certainly result in oscillation of the output, and not necessarily at audio frequencies. If this happens the IC will, for no visually or audibly apparent reason, get extremely hot extremely quickly, at which point it will shutdown due to thermal overload. The only way to detect this is with a very quick prod around the output pins with a scope probe before the chip shuts down!. C39 provides supply decoupling. A large value is required because of the high current surges produced by IC4, particularly with high volume low frequencies. R34 is the current limiting resistor for the power-on indicator LED1, and the last component actually fitted to the power amplifier section of the board is D1. This is connected directly across the incoming supply via fuse F1 to protect the whole circuit from reversed supply connections. If the supply lines are connected in reverse, D1 becomes forward biased and dumps all of the current into fuse F1, which will blow immediately. For this reason Fl should not be over-rated; doing so would result in the destruction of D1.

The final section of the circuit diagram is based around IC3b. This operational amplifier with its associated components R26, R27, VR7, C34 and C40 provides a mid-supply potential at its output (pin 7). This is used as a pseudo OV potential to bias the operational amplifiers in the preamplifier sections. By doing this the physical OV rail - the supply ground lead appears to the operational amplifiers as -6V, and the positive supply appears as +6V when referenced to the mid-rail point. C34 and C40 decouple and smooth the mid-rail supply. Preset potentiometer VR7 allows slight adjustment of the mid-rail voltage to compensate for discrepancies in the manufacturing tolerances of R26, R27 and the operational amplifiers themselves. Resistor R24 and capacitors C1, C2, C21 and C22 have the effect of filtering, smoothing and decoupling the supply rails to the sensitive parts of the circuit.

Construction

The PCB component layout diagram appears in figure 2, and although it might appear to be two separate boards held together by the heatsink, it is actually produced as one complete board. The PCB outlines serve only as an indication of where the board may be split in two, to provide a complete and separate power amplifier board if required. For clarity SW1 - the switch section of VR6 - has been omitted; the connections to this are included in the wiring diagram of figure 3.

There are no static sensitive devices on the board, so no special handling precautions are required. As with all PCB assembly work, begin by soldering in the lowest profile components first - wire links (of which there are a total of 11), resistors, VR7 and IC1, 2 & 3, working up to the highest profile components such as 104, the potentiometers VR1 to VR6 and C39, taking care to ensure the correct orientation of all the ICs, electrolytic capacitors, D1 and LED1. The length of bare wire spanning all of the potentiometers is soldered to the top of each of them and into the PCB to the left of VR1. Not only does this screen them from external noise (mains hum) but also reduces the mechanical ('crackling') noise produced by them to a minimum.

Once IC4 is in place, solder two suitable lengths of 16/0.2 wire to the speaker output pads, and at the same time, with a good layer of solder, build up the thickness of the copper tracks back to pins 8 & 10 of IC4. This needs to be done because these tracks will be carrying a significant amount of current at high volume, which could result in the tracks oxidizing and fracturing over a period of time, in much the same way as a fuse might blow for no apparent reason. Take care though not to bridge any other tracks whilst doing this, otherwise poor old IC4 might not live to forgive you for your mistakes. The power-on indicator LED1 should be mounted proud of the board by about 10mm to facilitate its positioning into the front panel during final assembly.

The heatsink should now be fitted to IC4. On the prototype this consisted of a piece of aluminium plate measuring approximately 120mm x 50mm x 3mm, if its anticipated that the unit is to be operated at high volume levels for long periods of time, it might be a good idea to use a longer piece of aluminium, or to have an additional commercial heatsink bolted on the back.

The easiest way to fit the heatsink is by first mounting the fixing bracket to the PCB in the position shown, then, by holding the aluminium against both the tab of IC4 and the bracket, mark through the holes of each of them where the aluminium needs to be drilled to accept M3 bolts.

The tab of IC4 is connected to pin 6 (GND) of the device, and so doesn't require an insulating kit between the tab and heatsink. However, since it's going to get rather hot at high volumes, it does require good thermal transfer from its tab to the heatsink, so it's best to apply heatsink compound to the reverse of the whole device before securing it, and don't forget to include the solder tag which fits to the front of the IC. Shakeproof washers should also be used during fitting, especially if the unit is to be subjected to prolonged mobile use where a lot of vibration occurs.

Assembly and wiring

Because even the best of us have our'off days', make a close visual check of the completed board for any dry joints, solder bridges etc.

Completion of the assembled unit will be made much easier (and neater) if all of the off-board wiring is soldered to the board first, rather than to the connectors themselves. In this way, the mechanical aspect of the construction (drilling the case, fitting the board, the sockets and fuseholder etc.) can be completed, leaving the task of soldering to the off-board components until last. Screened audio cable should be used for all of the low-level input and output sockets, and 16/0.2 stranded cable for the speaker and power connections. This might get a bit tricky around SW1 but it can, and must, be done in the manner shown. Connections

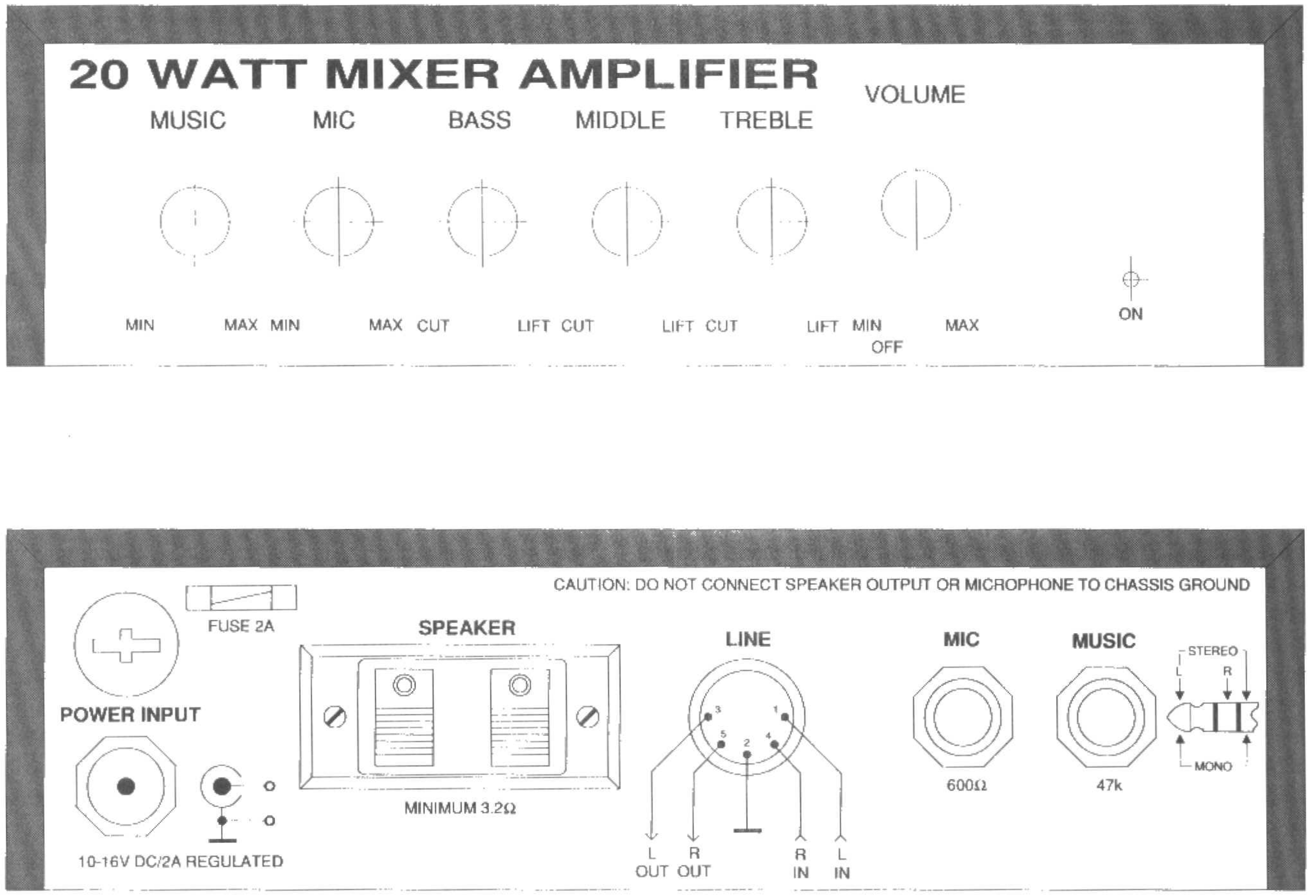


Fig.4. Front and back panel legends

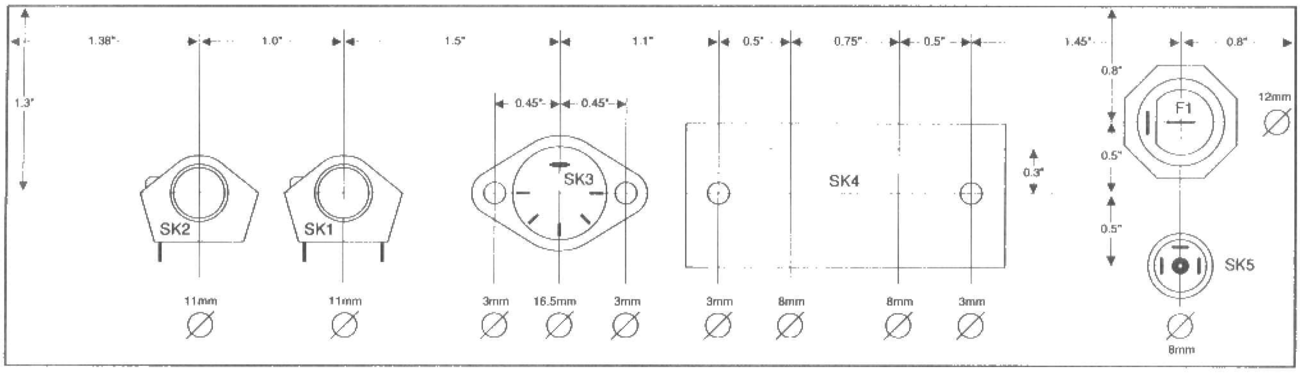


Fig.5. Position of rear panel mounted components (internal view).

from the switch to the power amplifier section MUST be kept as short as possible. At first glance it may seem a waste of effort to have two GND wires going to what looks to be effectively the same place, since they are joined by copper on the underside of the board (those being the PA GND on the PCB and the tab of IC4). But those of you with access to an oscilloscope will be able to see what effect it has on the loudspeaker output by leaving out just one of these wires. Similar constraints apply to the design of the copper track pattern of the power amplifier board itself. There are no sharp cornered tracks or square pads used here, and attempting to build this type of circuit on, say, stripboard would almost certainly fail to produce an amplifier - you're more likely to end up with some form of high frequency oscillating heater! Not to mention the headaches which ensue. With an incorrectly or badly designed board layout, it can be an absolute nightmare to get these devices to function reliably, and you are strongly recommended to use the one presented here. Suggested front and rear panel legends are shown in figure 4 and are designed to fit the enclosure used on the prototype, which, by the way, was a vinyl effect, steel topped, aluminium bottomed case measuring about 23C)mm x 133mm x 64mm, more commonly known in electronic circles as a WB4 case. The legends are produced here as a negative of those seen on the prototype, that is, what is black should be white, and vice versa. The reasons for this are; (1) they can be printed here with a cleaner, sharper definition than if a large black area had to be printed, and (2) you can take this page to your local reprographic printer, and for a modest cost get them to produce what is known as a negative bromide of them. The result is a very smooth matt finished black and white photographic label, which can be adhered to the case using either spray glue or 2" wide double-sided, self-adhesive tape. The labels won't be exceptionally hard wearing, but are ideal for purposes such as this, and will give your finished project an air of professionalism. If either of them does get damaged, simply get another one printed, peel off the old one, and stick on a new one.

Prior to fitting the PCB into position, fit a shakeproof washer to the bush of each of the potentiometers. Contrary to some people's beliefs, these actually go behind the panel, not in front of it. Nylon standoffs can be used to secure the back edge of the PCB to the case. These will prevent the back edge of the board from flapping around and shorting out on the bottom of the case.

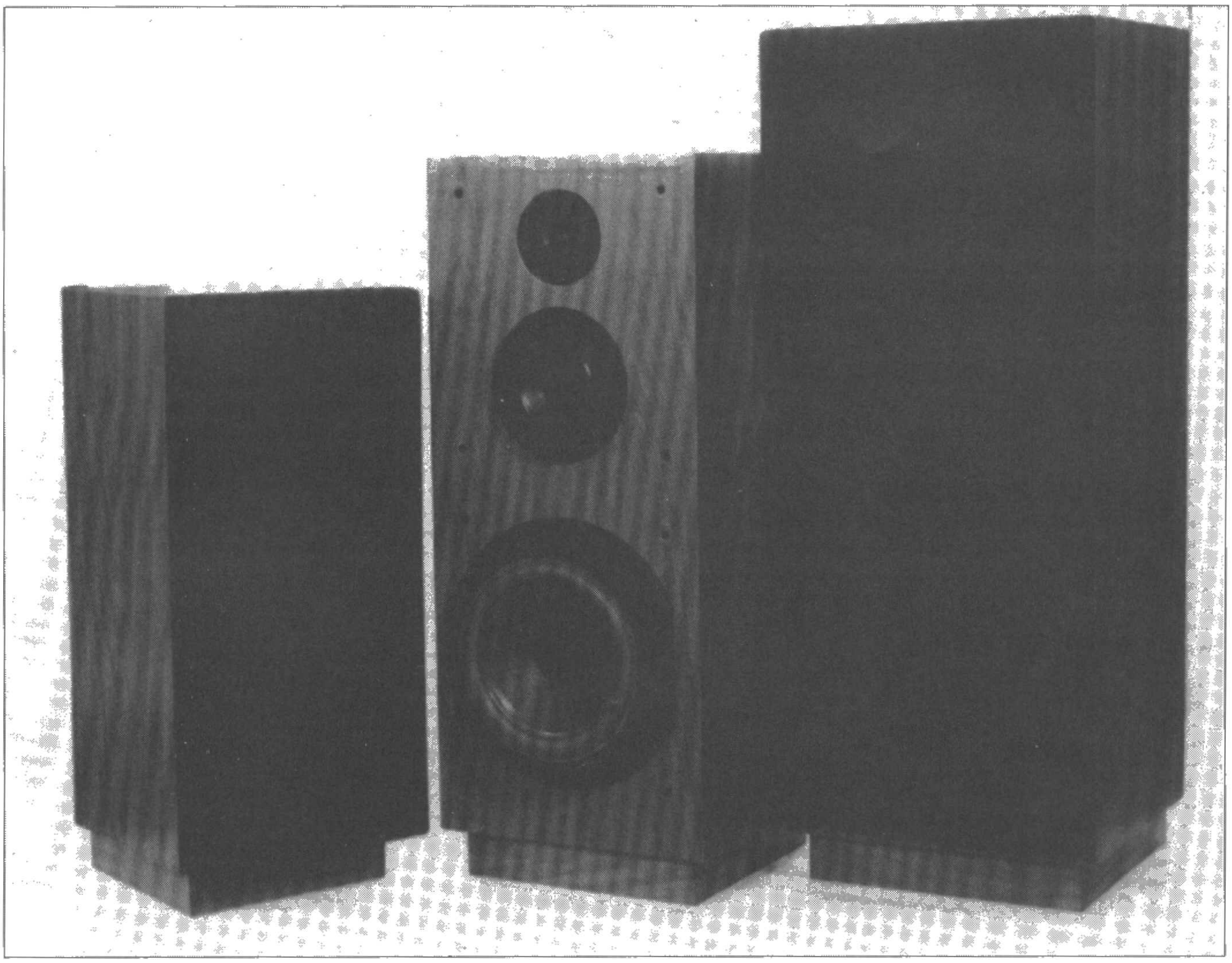
Fit the PCB with all its flying leads to the front panel, taking care not to damage the legend (if fitted). When tightening the locking nuts on the potentiometers, a tube or box spanner, or better still a pot nut spinner is the ideal tool for this job, but don't over-tighten them. Once the PCB is secured, bend LED1 so as to fit through the hole available for it in the front panel. It should protrude only very slightly through the front. Be careful not to short its legs together during positioning; no harm will result if they are, it just won't light up when you turn the power on.

Finally, fit the sockets, speaker terminals and fuseholder in their respective positions, and complete the wiring up in accordance with the wiring diagram of figure 3. Be sure to use an insulated socket for the microphone input SK1, as the common terminal of this input DOES NOT connect to the GND rail. The wire link shown across the fixed terminals ensures that the microphone socket is shorted out when the plug is removed. This reduces the risk of noise pickup and feedback if the microphone level control is turned full up with no microphone connected.

The loudspeaker terminals should be fitted with a plastic sleeve, or covered with insulation tape where they pass through the rear panel to prevent them coming into contact with it. The loudspeaker wires themselves are not polarized and each one can be connected to either terminal. On the prototype the 6-pin DIN socket SK3 was mounted on the inside of the case, but it can be a very 'fiddly' and time consuming job trying to hide the fixing screws in sufficiently large countersunk holes behind the rear panel legend, which obviously means it must be fitted to the panel before the legend is applied. An easier solution, although not as attractive, is to fit the socket on the outside of the panel. Alternatively, if you don't mind the expense, you could fit a more professional single hole fixing version, These are by far the easiest to fit, much the same as the fuseholder, and they look good too. But again, they are expensive.

Pay special attention to the wiring of the DC power socket SK5. The most common way for these to be connected is to have the negative lead to the centre pin and the positive to the outer case. But, for safety reasons, a break with convention is applied here, whereby the positive connection is made to the centre pin, and the negative to the outer case. This ensures that if a non isolated socket is fitted then the power supply ground lead, and NOT the positive supply line, will be connected to the case of the unit. If you do manage to get this wiring wrong, be sure you have a packet of spare 2A fuses to hand when you power up!

The power lead for the prototype consisted of a length of red and black figure 8 power flex or 'zip wire' as it is sometimes called. This is terminated at one end in a 2.5mm



DC power plug, again with the black negative lead connected to the outer of the plug and the red positive lead to the centre connection. The other end of the flex was fitted with insulated crocodile clips for direct connection to a car battery. These also made it possible to clip onto the output terminals of a good quality CB radio mains power supply unit, for indoor use. Cheaper power supplies may work OK, but the chances are that they might produce an unacceptable level of buzzing (mains hum) through the loudspeaker. If so, try connecting a 2200uF/25V capacitor across the output terminals of the power supply, taking care with its polarity. On a very serious note, we DO NOT recommend or condone operating the unit indoors from a car battery; remember, these types of batteries contain highly dangerous sulphuric acid. If you do use the amplifier indoors on a power supply that causes buzzing, and the above suggestion fails to cure it, get a better one.

In use

The mixer amplifier will operate from DC voltages as low as 6V, though the distortion will be high and the output power very much reduced at such a low voltage. Best results will be obtained from about 14.5V, but the maximum supply must not exceed 16V. Current-wise you're going to need at least a couple of Amps for full power. Lower currents will work for moderate volume output, but the distortion will be high at higher volume levels, and you also run the risk of burning out your power supply.

Once you're satisfied that everything is in order, set VR7 to mid-travel. The setting of this is not critical, but can be adjusted to give a voltage on pin 7 of IC3 which is half of the supply voltage. Once set, it can remain in that position for all supply voltages.

Connect a 3.2ohm - 16ohm loudspeaker to the speaker terminals, set the music and mic level controls to minimum (fully anti-clockwise), the volume control to the OFF position, and all three tone controls to mid travel. Apply power and switch on.

A moderate 'pop', click or thump should be heard from the loudspeaker, followed by a continuous almost inaudible hissing sound (white noise) - this is quite normal. Gradually increase the volume control until it reaches its maximum setting.

The noise should become more pronounced, but not severely. Now increase the mic level to its maximum setting. The noise at this point should be quite noticeable, and is nothing to worry about, since it is highly unlikely that these settings will ever be needed or used. Adjusting the settings of the tone controls will alter the 'colour' of the noise, and again this is quite normal. Lower noise levels can be obtained by replacing ICs 1, 2 and 3 with very high quality operational amplifiers such as the OP270 series, but the added expense will probably outweigh any real benefit.

Set the volume control to minimum and the mic, music and tone controls to about mid travel, plug in a 600R dynamic microphone (many other types should work too)

PARTS LIST

PH:RESISTORS

R1,9	2K2 (2 off)
R2,8,16,20	5K6 (4off)
R3,4,5,6,12, 21,22,23	47K (8off)
R7	390
R10, 11	22K (2off)
R14, 18	15K (2off)
R15,19	10K(2off)
R17	12K
R24	47K
R25	120K
R26	100K
R27	82K
R28	1K
R29,34	1K8 (2off)
R30,31	22ohm (2off)
R32,33	1ohm (2off)

POTENTIOMETERS

VR1,2,3,4,5	100Kohm LIN.PCB potentiometers (5off)
VR6	22Kohm LIN. PCB potentiometer with switch
VR7	47KR horizontal enclosed preset

CAPACITORS

C1,5,6,21,26,34	22uF/25V radial electrolytic (6 off)
C2,22,24,33 35,36,37,40	100nF polyester or ceramic(8 off)
C3,7,8,19,20,23,31	2u2/25V radial electrolytic (7 off)
C4,10	100pF ceramic (2 off)
C11,12,13	470nF polyester or ceramic (3 off)
C15	4n7 polyester or ceramic
C17	3n3 polyester or ceramic
C18	33pF ceramic
C25	22uF/25V axial electrolytic
C27,28,38	220uF/25V radial electrolytic (3 off)
C29,30,32	100uF/25V radial electrolytic (3 off)
C39	1000uF/25V radial electrolytic

SEMICONDUCTORS

IC1,2,3	RC4558 dual op-amp (3 off)
IC4	TDA2005M 20 watt bridge amplifier IC
D1	1N5401 3 Amp silicon rectifier diode
LED1	3mm standard red LED

HARDWARE & MISCELLANEOUS

F1	2 AMP 20mm quick-blow fuse
20mm panel mounting fuseholder	
S1a,b	DPST switch - part of VR6
SK1	1/4" mono switched jack socket
SK2	1/4" stereo unswitched jack socket
SK3	180" 5-pin DIN panel mounting socket
SK4	2-way quick-connect speaker terminals
SK5	2.5mm DC power socket
Plug	2.5mm DC power plug to suit above *
Knobs	control knobs (6 off)
Heatsink	120mm x 50mm x 3mm aluminium plate
Small fixing bracket	
Nylon standoffs (2 off)	
M3 fixing hardware (screws, nuts, washers)	
M3 solder tag	
Twin screened cable ('/z metre approx.)	
16/02 red connecting wire (300mm)	
16/02 black connecting wire (300mm)	
16/02 other colour wire (300mm)	
Red+black fig.8 power cable (3 metres)*	
Large red insulated crocodile clip *	
Large black insulated crocodile clip *	
Case	aluminium/steel enclosure *
Feet	medium size self adhesive feet (4 off)
PCB	DTE 2c20 printed circuit board
Legends	front and rear panel labels *

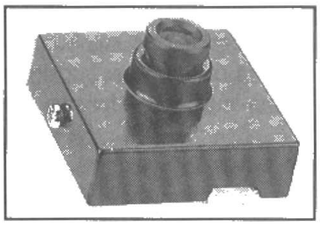
*Not supplied with the kit

and apply a music source to the music input. Always use a stereo jack plug for the music input, if only a mono signal is available it can be applied to either the left or right channel input, leaving the other channel unconnected. If a mono jack plug is used, resistor R5 will be shorted to ground. This will cause no harm but it will effectively reduce the level of the incoming signal.

Whilst on the subject of shorting things out, it's worth remembering that the microphone must be connected separately to the music input. Do not to connect the microphone's common lead to the common lead of the music signal, as this would result in the possible damage to the output of IC3b, which would in this condition be connected to the supply ground terminal.

The 5-pin DIN output (pins 5 & 3) can be fed to a hi-fi amplifier for more output, a tape recorder for recording the mixed signals, or to a video recorder equipped with audio dubbing facilities to add a sound track or commentary to home videos. Whichever your preference, happy mixing.

A complete kit of component parts (which includes the PCB, heatsink, sockets, cable and knobs etc, but excludes the case and any other items marked *) is available from the author by mail order only at the following address:-
DTE Micro Systems, 112 Shobnall Road, Burton on Trent, Staffordshire DE14 2BB.
The price for the kit of components as listed above is £34.00. The PCB can be purchased separately if required for £8.00.
Please add Postage & Handling to complete order:- £2.50 (UK) £4.00 (elsewhere)
Please make cheques/Postal Orders payable to 'DTE MICRO SYSTEMS'. If ordering from overseas, payment must be in pounds sterling (£) and cheques must be drawn on a British bank.
Goods will normally be dispatched within five working days from receipt of order (subject to stock availability and cheque clearance), but please allow up to 28 days for delivery.



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SOUND TALLY

Terry Balbirnie's nine-event noise counter

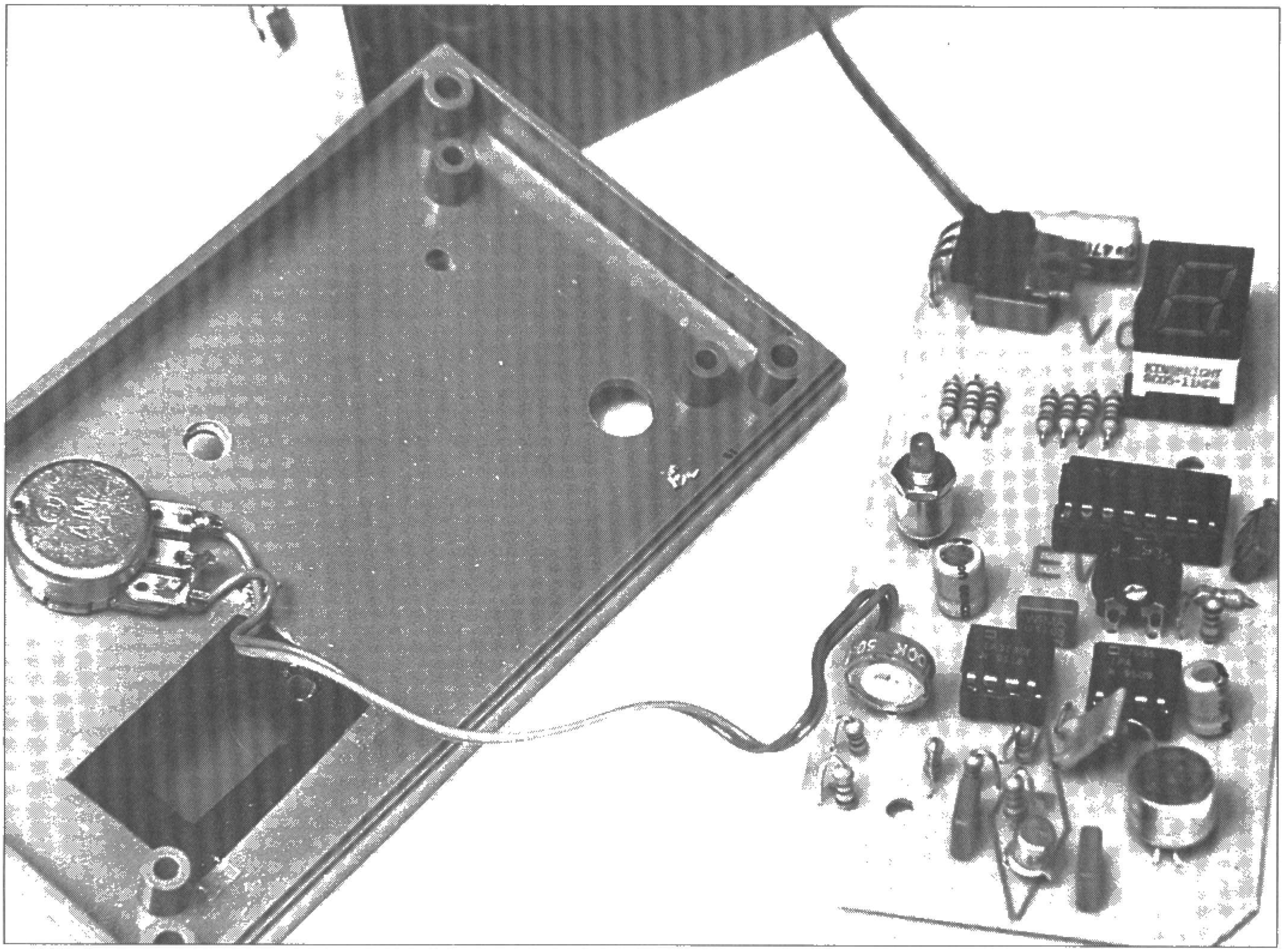
Sound Tally will display the number of times a noise has been made since it was last reset. Typical uses include counting how many times the doorbell or phone has rung. It could also be used to record the number of times a door, window, etc has been opened or disturbed . Monitoring a phone or doorbell will involve siting the unit very close to the source of sound. However, closing doors, drawers, windows, etc will operate the unit over a distance of several metres.

Apart from the power supply, the device is self-contained with an inbuilt microphone to pick up the sound. A panel-mounted sensitivity control is adjusted for best effect and a push-button reset switch used to return the counter to zero. The unit is then left to register events on a 7-segment LED display. A maximum count of nine is available and this will be found sufficient for most purposes.

The circuit is operated by a commercial plug-in power supply unit. It is therefore necessary to have a mains socket available reasonably near the point of use. The maximum current requirement is about 120mA (that is, with all LED segments illuminated) and any 300mA regulated or unregulated d.c. supply having an output of 7 to 12 volts may be used.

All lit up

The system works best for counting sounds in an otherwise reasonably quiet environment.



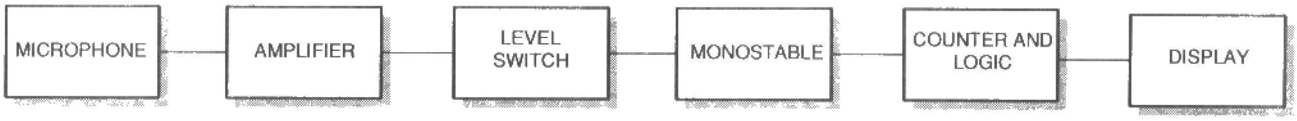


Fig.1. Sound tally block diagram

For example, to indicate the number of times the doorbell has rung while the house is unoccupied. The effect of extraneous noise is greatly reduced by careful siting of the unit and adjusting the sensitivity to the lowest setting consistent with reliable operation. If there are likely to be loud, sudden sounds such as slamming doors or barking dogs in the house, the device may not be suitable and will possibly register false counts. For this reason, it should not be used where spurious operation would prove to be a nuisance.

An important feature of the circuit is an adjustable insensitive period or dead time. Thus, when a sound has been registered, the circuit will not respond to further ones picked up during this period. This is useful because, in many cases, a single event will provide several pulses. For example, if it were used to monitor a doorbell, a visitor would be likely to operate it several times before giving up. If the dead time was adjusted to, say, 30 seconds it would eliminate the effect by responding to the first ring only. The dead time will also prevent the ding-dong of door chimes or the double ring of a phone from being registered twice. Of course, this does not provide totally foolproof operation. It could miss a new event which happens to be given during the dead time especially if this has been set too high. As described, the dead time may be adjusted between 1 and 50 seconds approximately. It could be increased very easily if this was found necessary.

How it works

Operation of the Sound Tally is illustrated by the block diagram shown in Figure 1. Sound is picked up by the microphone, the signal amplified and applied to a level switch. This latter section will provide one sharp output pulse each time the sound exceeds a certain volume. The output from this triggers the monostable which gives a high output for a certain time before going low again. While high, further trigger pulses have no effect and this provides the dead time aspect. The monostable output is applied to the counter and logic circuit which operates the display.

The complete circuit diagram is shown in Figure 2. Regulator, IC5, and capacitors C7 and C8 operate in conjunction with the external power supply to provide a precise 5V output. Operating the circuit from a fixed supply voltage provides consistent operation.

Electret microphone, MIC1, detects any incoming sound. It needs a supply to operate its own internal pre-amplifier and this is derived from the +5V line through resistor, R1. The output from the microphone is coupled via capacitor, C1, to the base of high-gain transistor Q1. Resistor R2 sets the bias while R3 is the load resistor. Ignoring the effect of any sound picked up by the microphone for the moment, the bias will result in a steady d.c. voltage appearing at the collector. Capacitor, C2, blocks this so it has no further effect.

On the level

The section consisting of operational amplifier, IC1, and associated components forms the level circuit and is based on a voltage comparator. When the voltage applied to the non-inverting input (pin 3) exceeds that at the inverting one (pin 2), the output (pin 6) will be high. In other cases it is low.

Disregarding R7 for the moment, both op-amp inputs receive voltages derived from potential dividers connected across the 5V supply. Equal value resistors, R4 and R5, apply a constant voltage equal to one-half that of the supply to the non-inverting input, pin 3. Fixed resistor R6, in conjunction with preset RV1 and potentiometer RV2 connected as a variable resistor, apply an adjustable voltage to the inverting input, pin 2. RV1 will be adjusted at the setting-up stage so that slightly less than one-half supply voltage appears at pin 2 when panel-mounted sensitivity control, RV2, is adjusted to maximum resistance (providing the most sensitive setting). Since the inverting input voltage is less than the non-inverting one, the op-amp output (pin 6) will be high. When a sound is detected by the microphone, its low-level a.c. output is amplified by Q1 and a signal flows from the collector to the op-amp non-inverting input via capacitor C2. The voltage here will now fluctuate about its mean value. If it is loud enough, it will fall below the voltage at the inverting input on the negative peaks.

Each time this happens, the op-amp output will switch off for an instant (i.e. pin 6 goes low). Resistor R7 applies a little positive feedback to ensure a very sharp switching action. Sensitivity control, RV2, determines the extent by which the inverting input voltage exceeds the non-inverting one. It will take a louder sound to trigger the level circuit if there is a wide difference between these two voltages.

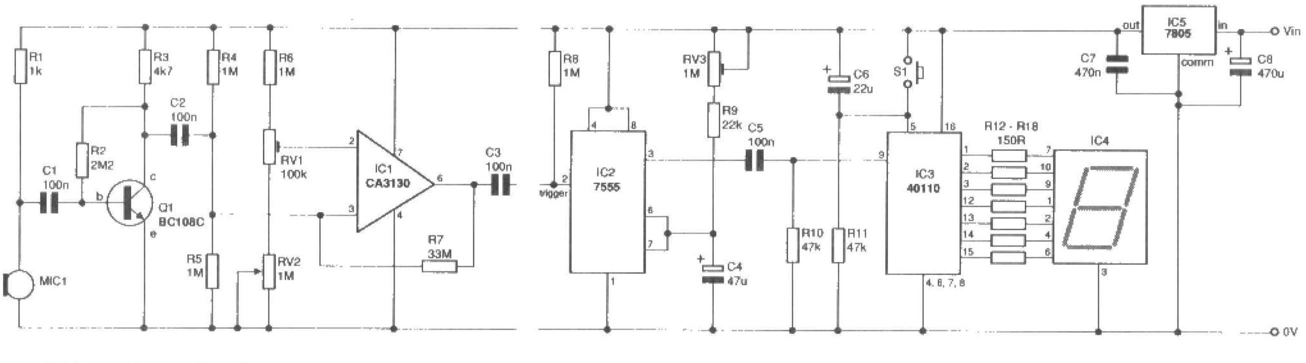


Fig.2. Sound Tally circuit

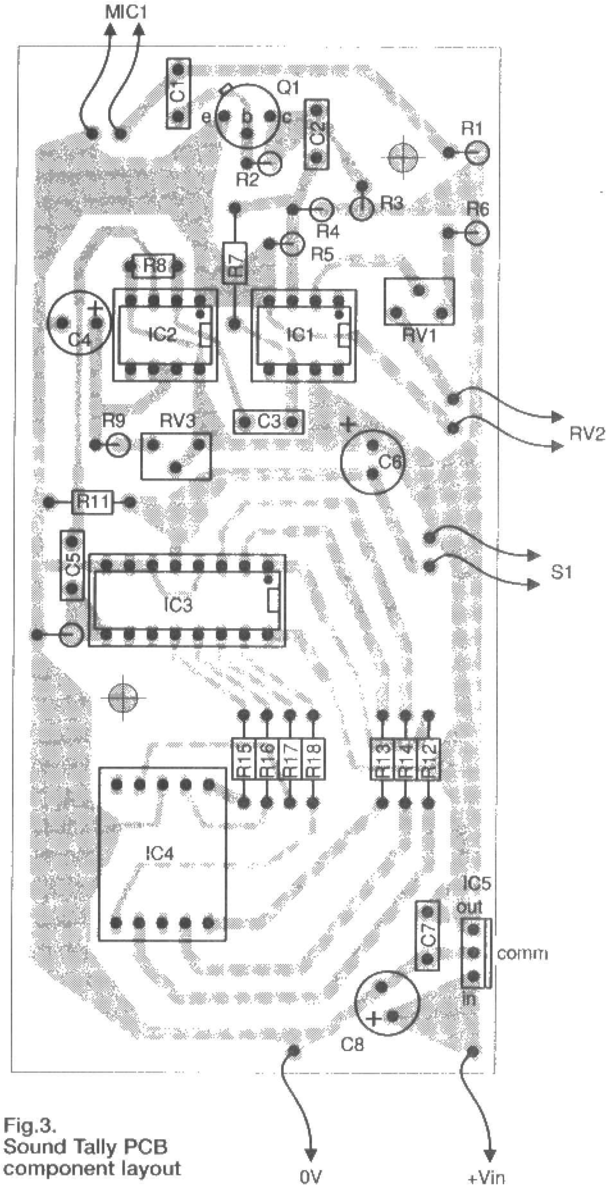


Fig.3.
Sound Tally PCB component layout

Slow pulse

The monostable consists of timer integrated circuit IC2 and associated components. When IC1 output goes low, capacitor C3 will allow this state to pass to IC2 pin 2 (trigger input) and this initiates a timing cycle. To prevent false operation, pin 2 is kept normally high by resistor, R8. The monostable time period is related to the values of fixed resistor, R9, preset potentiometer RV3 (connected as a variable resistor) and capacitor, C4. With those specified, it may be adjusted between 1 second (with RV3 set to zero resistance) and 50 seconds (with RV3 at maximum) approximately. Any further pulses applied to pin 2 during this time have no effect. The period could be increased by raising the value of C4 in proportion.

Integrated circuit counter IC3 accepts a high state at its clock input, pin 9, and initiates a count. This device contains all the counting, logic and driving circuitry needed to operate the LED display, 1C4. With each pulse of the monostable, IC2 pin 3 will provide an input to IC3 pin 9 through capacitor, C5. IC3 outputs (pins 1, 2, 3, 12, 13, 14 and 15) will then go high in the correct combinations to operate the appropriate LED segments and thus form the digits O to 9 in turn. Each segment has its own current-limiting resistor, R12 to R18. Pin 5 is left unconnected since this is the decimal point which is not used. Pin 8 is also unconnected since this is a duplication of pin 3 which is the common cathode (negative) connection for all seven segments.

The counter is returned to zero by making IC3 reset input (pin 5) high for an instant and this is done by pressing switch, S1. Resistor R11 keeps this pin normally low to prevent false resetting. Capacitor, C6, keeps it high for one second approximately after the switch has been released. This maintains the i.c. in a reset condition until C6 has charged sufficiently through R11. During this time it will be insensitive to any pulses applied to pin 9. Without this, the microphone would probably receive sufficient sound from the action of the switch, hands on the case, etc. to register a false count.

Construction

Figure 3 shows the component overlay for the printed circuit board. Begin by drilling the two mounting holes in the positions indicated. Solder the sockets for IC1, IC2 and IC3 in place. The LED display, IC4, has 10 pins arranged in two rows of five and having a spacing of 15mm between the rows. This is a rather unusual arrangement and a suitable socket will probably not be available "off the shelf".

Possibly the easiest way to proceed is to cut a standard 14-pin socket along the middle and file off two pins from each half. The individual sections of five pins each are then mounted separately on the PCB. Alternatively, two pieces of single in-line socket could be used. Note that a socket should be used for the display rather than to solder it direct to the PCB.

This avoids possible damage due to heat from the soldering iron. It also raises the face of the unit above other components so that it will locate correctly behind the hole which will be made for it in the top of the case. Mount all resistors including the two presets. Note that the seven components labelled "R" in Figure 3 are resistors R12 to R18 in the circuit diagram (Figure 2) and are all identical 150 ohm units.

Resistor R7 has an unusually high value and may only be available in a rather large case style. Sufficient space has been left on the PCB to accommodate one of these if necessary. It would also be possible to use three 10 megohm resistors connected in series zig-zag fashion. Add the capacitors taking care over the polarity of C4, C6 and C8. Note that C8 is mounted with its body flat on the circuit panel. Mount transistor Q1, again, taking care over the orientation. Solder regulator, IC5, into position using the full length of the pins. Carefully bend these at rightangles so that the body lies flat and clear of C7 and C8. The metal backing should now face the PCB (see photograph).

Its own pad

Solder the microphone in position. First, look at its underside - one pin or pad will be seen to be connected to the metal case. This is the ground (supply negative) one and it should be soldered to the lower pad on the PCB (i.e. the large land area). The top face should stand about IOmm above the PCB. If the microphone has pad rather than pin connections, it will be necessary to solder short "stalks" made of bare wire to the pads first. The specified sub-miniature switch, S1, may be mounted on the circuit board. A larger switch may need to be connected off-board. Solder pieces of stranded connecting wire to the pads labelled "+V in" , "0V" and "RV2" (2 off). Adjust RV1 and RV3 both fully clockwise (as viewed from the left-hand edge of the circuit panel). This will provide minimum sensitivity and dead time.

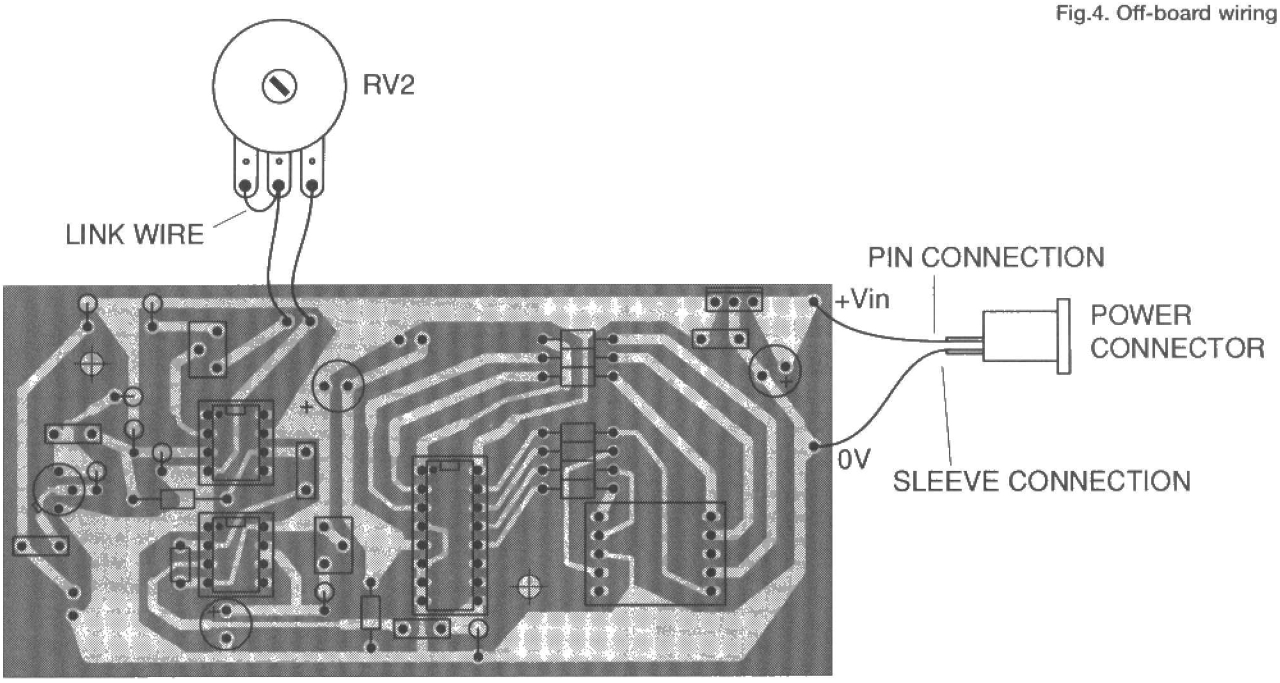


Fig.4. Off-board wiring

Prepare the case for the PCB. Drill the holes to correspond with those made in the panel. Carefully measure the position of the display, microphone and reset switch and make holes for these components.

Note that only the switch button protrudes through its hole - not the threaded barrel. Cut the hole for the display slightly smaller than the display itself. The best method is to mark it out, drill a series of holes inside the line and remove the plastic. The hole may then be filed to size. The hole for the microphone should be the same diameter as its body - 10mm approximately.

A small vice

Cut RV2 (sensitivity control) spindle to the correct length before fitting this component. Do this by gripping the spindle - not the body - in a small vice. The spindle may then be cut using a hacksaw. If a miniature potentiometer is used, it should be possible to mount it on the lid above the PCB in the region of resistors R12 - R18 (see photograph).

Check that this is possible before drilling the mounting hole and make sure that it will not cause any short-circuits especially at the tags. If there is found to be too little clearance, or if in doubt, mount it on the side of the box instead.

Mount the circuit panel temporarily on 10mm long plastic stand-off insulators. Make any adjustments as necessary so that the display and microphone take up a position just below the holes made for them and the reset switch button protrudes through its hole. With the specified box, the corners of the PCB will need to be filed off to clear the lid fixing bushes. The PCB must now be removed again to allow for adjustment of presets RV1 and RV3 later.

If the reset switch is to be mounted separately, drill a hole in the side of the case and attach it. Make a hole also for the power socket and secure this. Mount RV2 either on the lid or on the side as decided previously. Refer to Figure 4 and complete the wiring. Note that RV2 has two of its tags interconnected. As viewed from the rear, these are the centre and left-hand ones as shown. Connect the centre (pin) connection of the power socket to the wire leading to the "+Vin" pad on the PCB. Insert the i.c's into their sockets observing the orientation. IC1, IC2 and IC3 are CMOS components and could be damaged by static charge which may exist on the body. It would therefore be wise to touch something which is earthed (such as a water tap) before handling the pins. Note that the decimal point end of the display is the one closest to IC3. Fit RV2 control knob and adjust the spindle fully anti-clockwise (for minimum sensitivity).

Testing

Work in a quiet place so that triggering does not occur with random sounds. Check the polarity of the power supply before connecting it and reverse the polarity plug, if necessary, so that the centre (pin) connection is the positive one.

Connect it to the unit, plug it into the mains and switch on. If the display does not show zero, press the reset button so that it does. If the instructions were followed correctly, RV1 and RV2 will have been left adjusted for minimum sensitivity. The microphone will therefore need a loud sound to provide a count. Clapping the hands or tapping the unit should do this. By adjusting RV2 clockwise, it will be found that quieter sounds will provide a count.

It is now necessary to adjust RV1 to provide most sensitive stable operation when RV2 is adjusted to maximum. To do this, adjust RV2 fully clockwise (maximum sensitivity) and rotate RV1 sliding contact slowly anti-clockwise. At a certain point, counting will take place in the absence of any sound. Re-adjust it clockwise until the display remains steady. Do not aim for the absolute maximum sensitivity or the unit will be unstable in use.

The dead time should now be adjusted using RV3. This will be done taking account of the purpose to which the unit will be put. For many applications, mid-track position will be about right (providing 25 seconds approximately).

Clap hands

When the unit has been adjusted correctly, attach the red filter under the hole for the display using double-sided Sellotape or a little quicksetting glue. Although proper display filter material is obtainable this is not really necessary. Any piece of transparent plastic could be used providing it has a similar red colour to that of the display. Attach the PCB and make final trials before putting the device put into service.

Hint: Depending on the sensitivity setting and siting, the unit may trigger when the door is closed on leaving the house. To prevent a count being registered, use a long dead time. Clap the hands to give a count, press the reset button and leave within this time.

Buy Lines

A suitable switch for PCB mounting is Maplin JMO1B. Resistor R7 may also be obtained from Maplin as a "high voltage" resistor - its order code is V33M.

PARTS LIST

Resistors

R1	1K
R2	2M2
R3	4K7
R4, R5, R8, R8	1M
R7	33M (see text)
R9	22K
R10, R11	47K
R12-R18	150R - 7 off
All fixed resistors 0.25W 5%	
RV1	100k min vert preset
RV2	1M min potentiometer
RV3	1M min vert preset

Capacitors

C1,C2,C3,C5	100n metallised polyester 5mm pin spacing.
C4	47u 25V radial elect.
C6	22u 25V radial elect.
C7	470n metallised polyester 5mm pin spacing.
C8	470u 16V radial elect.

Semiconductors

IC1	CA31 30E
IC2	ICM75551PA
IC3	40110B
IC4	0.5 in. common cathode LED display
IC5	L7805CV 5V 1A regulator
Q1	BC108C

Miscellaneous

S1	Sub-min push-to-make switch (see text)
MIC	Miniature electret microphone insert 10mm diameter approx. Preferably pin connections - see text.
	8-pin d.i.l. sockets - 2 off.
	16-pin d.i.l. socket
	Socket for LED display see text.
	7 - 12V d.c. 300mA plug-in power supply unit.
	Power socket.
	Plastic box size 125 x 70 x 49 mm.
	Stand-off insulators - 2 off.
	Control knob for RV2.
	Red filter material for display.
	Small hardware.

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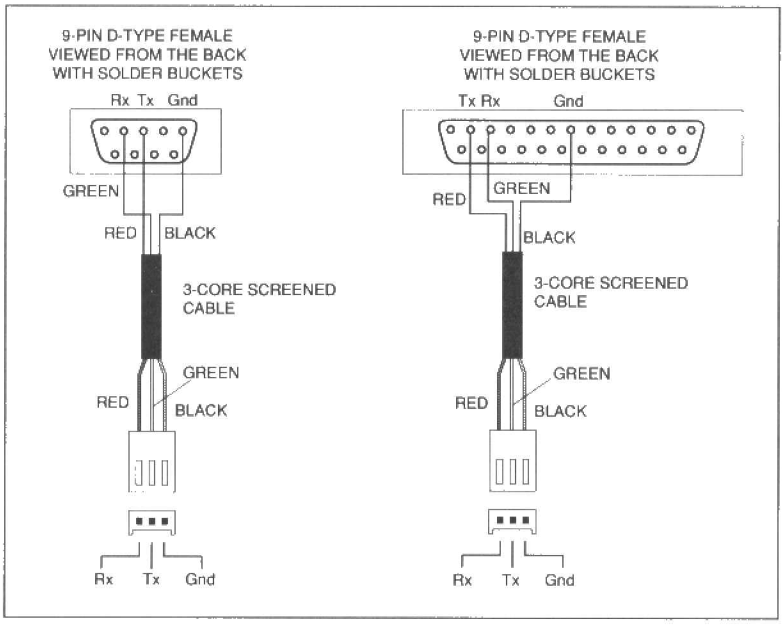
8031 & 80535 Single Board Computer

PART 3

Dr PEI AN continues this project with a look at the construction of the SBC



In Parts I and II we have looked at the detail of the circuit of the MCS-51 single board computer system. In this part we are giving the construction details. The complete SBC system including the hardware and software is available in kit and assembled forms from the author.

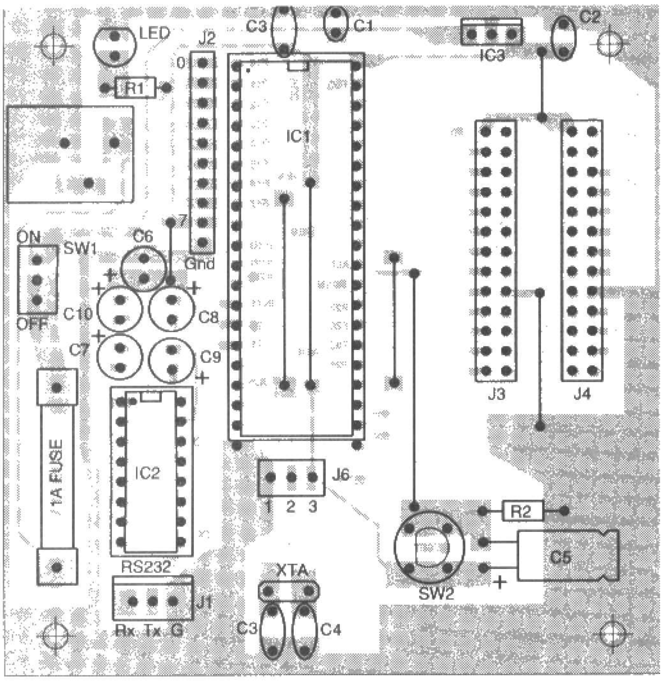
The main features of the board and the circuit diagram have been detailed in Part I. The board consists of an 8031 microcontroller (IC1), a RS232 line driver (TC232, IC2) and some peripheral components. It has a +5V 1A voltage regulator (7805, IC3) and requires an external 8-15V DC power supply. An on/off switch, an 1 A fuse and a LED indicator are also provided. The MCS-51 bus (including data, address lines) is available from two identical 26-pin IDC connectors (J3 and J4), from which the memory and I/O expansion board and other interfacing cards can be connected. Port 1 of the 8031 is available from a 10-way PCB connector (J2). The port can be used as a general purpose 8-bit programmable I/O port. J1 is the connector for an RS232 serial cable which links the SBC and the computer when the SBC runs in the pc operation mode. Pin layouts of J1, J2, J3 and J4 are shown in Figure 1.

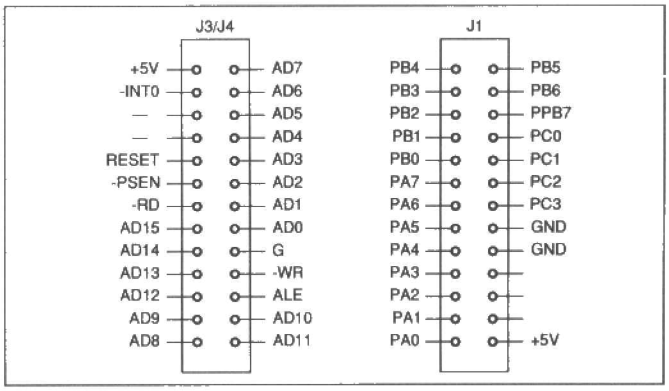
The motherboard is constructed on a single-sided PCB board. The component layout is shown in Figure 1. General guidelines in constructing the board are given in 'Construction Notes'. As the complete SBC system consumes about 0.5 A, a heat sink must be installed on the voltage regulator to prevent it from overheating. The board is simple to construct and there is no adjustment needed. Hence, it should work straight away once it is properly constructed. The wiring of the RS232 cable is given in Figure 2. The figure shows two types of RS232 connectors on the pc's side, 9-pin and 25-pin D-type connectors.

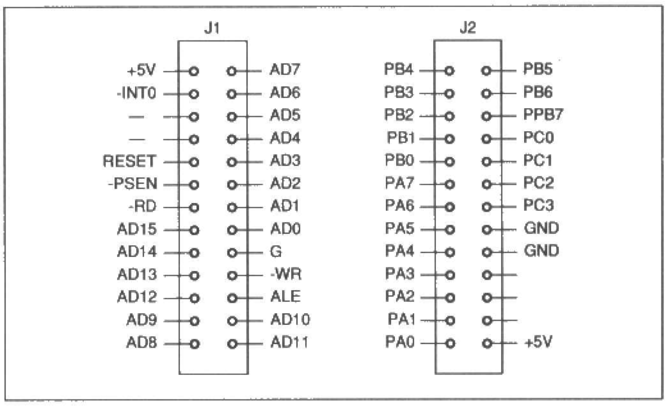
This board can be used as the motherboard in this SBC system. It can also be used as a stand-alone microcontroller board for other applications. 8031, 8051 or 8751 microcontrollers can be used on the board. If the microcontroller fetches data from an external ROM, Pins 1 and 2 of J6 should be connected using jumpers. If it fetches data from the internal ROM (for 8051 and 8751 only), Pins 3 and 2 should be connected.

Memory and I/O expansion board

The main features and the circuit diagram of the board have been given in Part I. The board consists of an 8 kilobyte CMOS RAM (IC4, 6116), a 16 kbyte EPROM (IC5, 27128), an 8155







peripheral programmable interface chip and an address decoding circuit built around one 74LS08 and two 74LS138 ICs (IC2, IC3 and IC6). The board is connected to the motherboard via the bus expansion socket (J1) using a ribbon cable. The 8155 provides two programmable 8-bit I/O ports and one 6-bit I/O port. These ports are available from the I/O expansion connector (J2). It is used for connecting the display/keyboard or other I/O expansion boards. The pin functions of J1 and J2 are shown in Figure 3.

The monitor software of the SBC is stored in the 27128 EPROM. The keyboard monitor program is stored in the lower 8 kbyte memory space and the PC monitor program is stored in the upper 8 kbyte space. SW1 is for selecting either the keyboard or the pc monitoring modes (SW1). If the switch is set to the right-hand side, the keyboard monitor is selected. If it is switched to the left-hand side, the PC monitor is selected. The second switch on the board (SW2) is for selecting either single-step or continuous program executing modes. If it is switched to the right-hand side, continuous mode is selected. If it is switched to the left-hand side, single-step mode is selected. A 3.6V rechargeable battery is installed on the board to backup the data stored in the CMOS memory (6116).

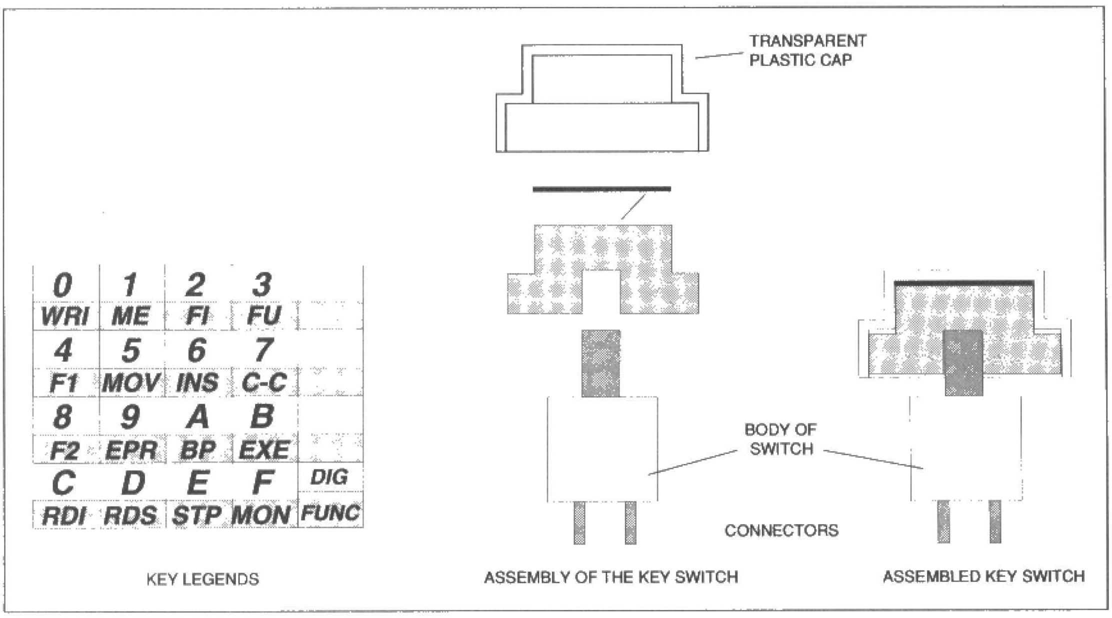
Once the battery is fully recharged, it is able to backup the data in the memory for several months. A sounder is installed for generating audible sounds. However, it can only work under pc monitor mode.

Resistor R4 (pull up resistor for -WR pin of IC4) is a surface mount device and is mounted onto the copper tracks of the PCB. It is recommended that IC sockets are used for 6116, 27128 and 74HC573 which are CMOS devices. After soldering all other components, these ICs are inserted into the sockets. There is no adjustment required. The board will work straight away if all the components are mounted correctly.

This board can also be used for other applications. Users can replace the present 27128 EPROM which stores the SBC monitor with their own programmed EPROMs.

Display and keyboard

The main features of the board and the circuit diagram have been given in Part I. This board comprises six common-cathode 7-segment displays, a multi-function 4x4 matrix keypad and a control key. The board is connected to the memory and I/O expansion board via the I/O expansion connector (J1) using a ribbon cable. In the keyboard monitor mode, the four digits from the left to right display the address



of a memory location. The two digits on the right show data in that memory location.

Each key in the keypad has two functions, one for numbers (0-F) and one for program editing controls. The two functions are selected by pressing the control key. The details of the keyboard operation are given in Part III and in the user's manual of the board.

The key legends are given in Figure 5. They should be cut and placed underneath the caps of the keyboard switches as shown in Figure 5.

Construction notes

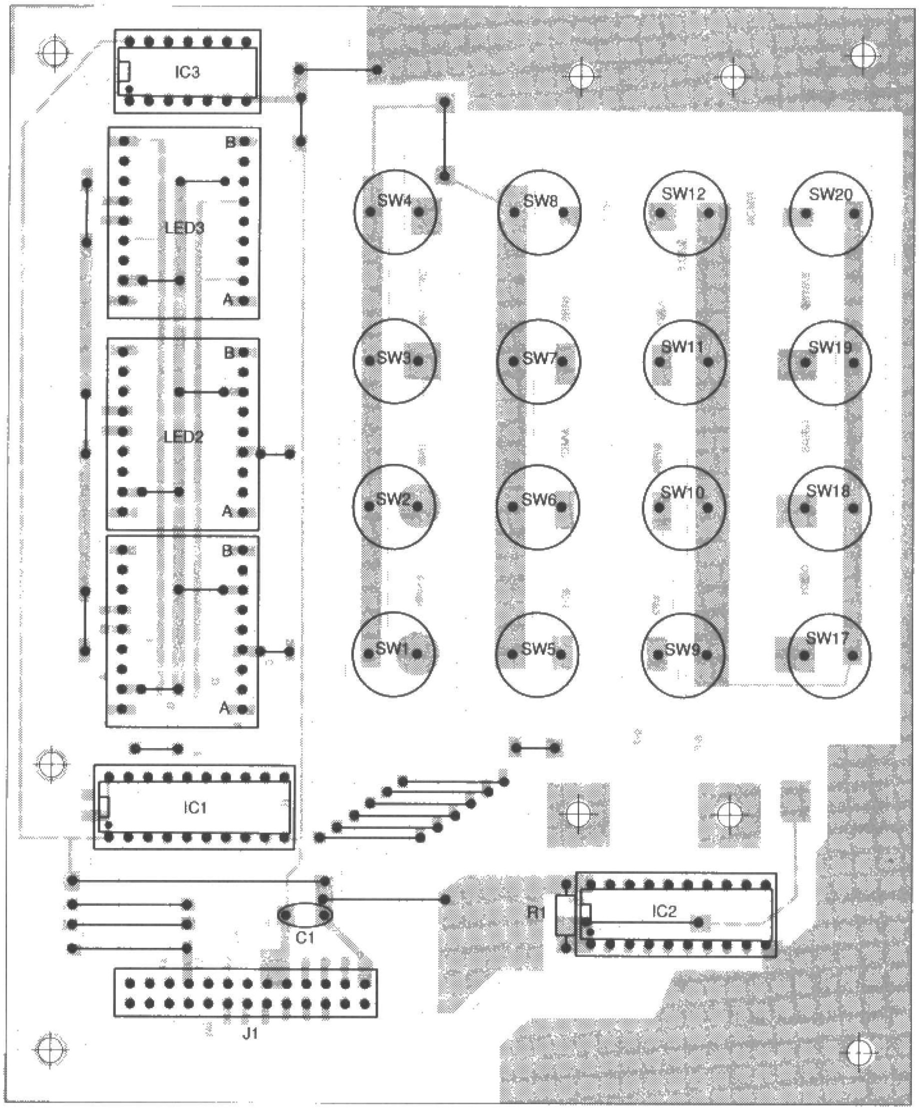
The following notes apply to the construction of all boards.

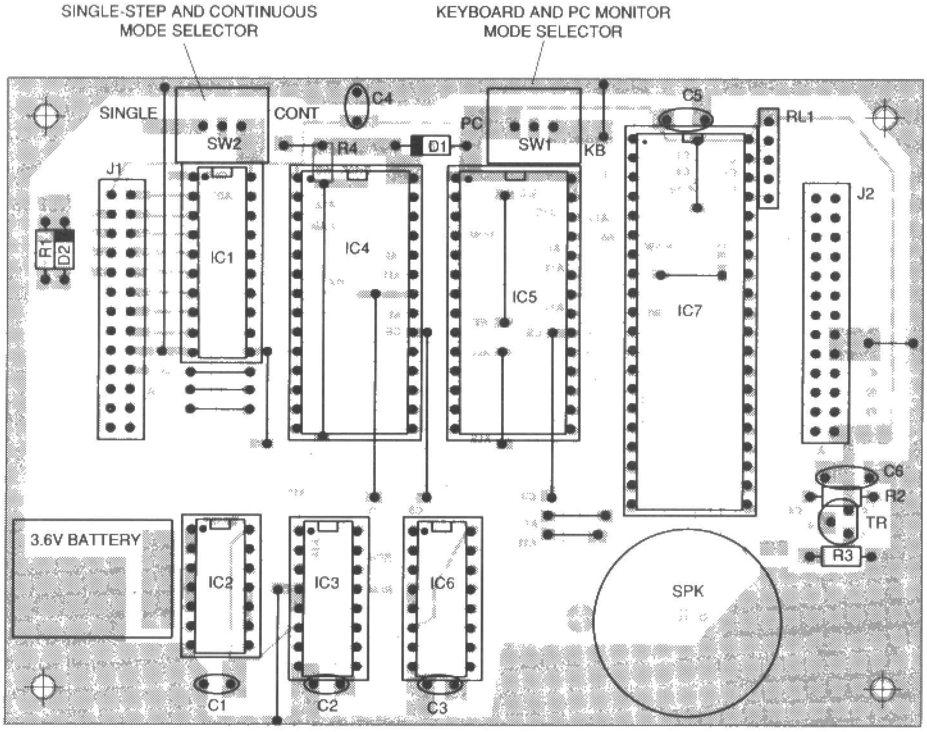
Before soldering the components on the PCB boards, a careful inspection of the PCB must be carried out to check if there are unwanted joints or cuts. Components should be soldered on the board in the following order: links, resistors, diodes, IC sockets, capacitors, connectors, etc.

After soldering, another careful inspection must be carried out to check if there are bad soldering points.

Then chips can be inserted into the sockets.

Before connecting the power supply to the board, check again carefully if all the components are in the right places and in the right direction.





Final assembly

The 8031 motherboard, memory and I/O board and display and keyboard are connected together using 26-way ribbon cables. An 8-15V DC power supply is used to power the SBC system.

The complete system in total consumes about 0.5A.

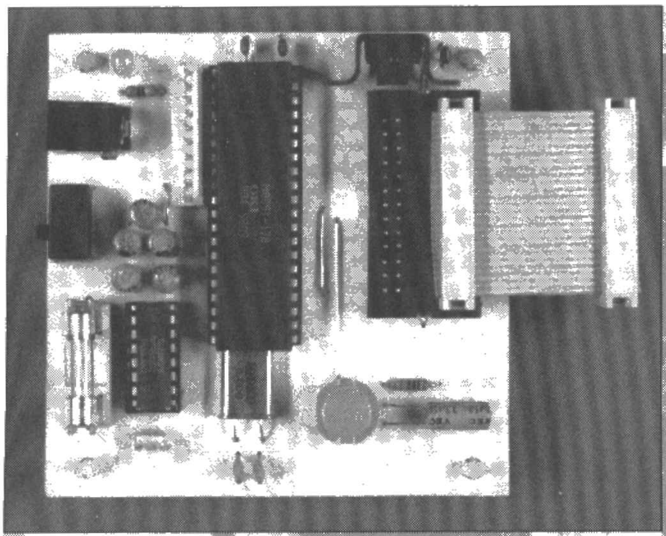
After all the boards are connected together, test the keyboard mode and make sure that SW1 is switched to the right-hand side for the keyboard mode.

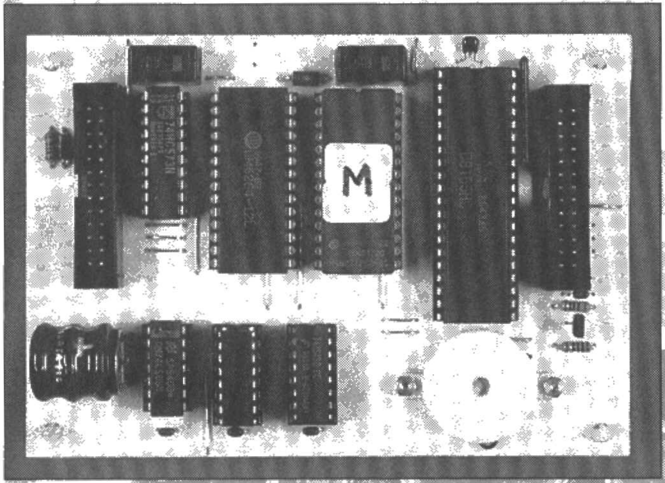
When the power to the SBC is turned on, the power indicator LED will be lit. Simultaneously, the display on the display/keyboard will prompt 'IIE-51'.

This indicates that the SBC is working. Kits and workshop manuals are available from the author:

Dr. Pei An, 58 Lamport Court,
Lamport Close, Manchester M1 7EG, U.K. Tel/Fax/Answer: +44-(0)161-272-8279.

Next month we conclude this project, with a look at the keyboard unit.





PARTS LIST

8031 motherboard

Capacitors

C1-C3	100nF ceramic disc capacitor
C3,C4	22pF ceramic disc capacitor
C5	10µF electrolytic capacitor
C6-C10	22µF electrolytic capacitor

Resistors

R1	390R
R2	1K

Semiconductors

IC1	8031 microcontroller
IC2	TC232 RS232 driver
IC3	7805 +5V 1A voltage regulator
LED	Red LED

Others

J1	3-way PCB connector
J2	10-way PCB connector
J3, J4	26-way IDC male connector
J5	Fuse holder
J6	3-way SIL PCB pins
SK1	2.5mm Power connector
SW1	Side-slide miniture switch
Fuse	1A fuse
XTA	6MHz crystal
SW2	Press-to-make click switch
HS	Heat sink for the voltage regulator
PCB	PCB board of the 8031 motherboard

Memory and I/O expansion board

Capacitors

C1-C6	100 nF ceramic disc capacitor

Resistors

R1,R3	1K
R2	100R
R4	10K surface mount resistor
RL1	8-way 5.1K resistor array

Semiconductors

IC1	74LS573 D latches
IC2	74LS08 or gate
IC3,6	74LS138 3-8 line decoder
IC4	6264 8 kbyte CMOS memory
IC5	27128 16kbyte EPROM
IC7	8155 peripheral programmable interface
D1,2	1N4001
TR	ZTX300

Others

J1,J2	26-way IDC male connectors
SW1,SW2	Switches
SPK	Sounder
3.6V	Rechargeable Battery
PCB	PCB board of the memory and display board

Display and keyboard

Capacitors

C1	100nF ceramic disc capacitor

Resistors

R1	4K

Semiconductors

IC1	74LS245
IC2	74LS241
IC3	7406
LED1,3	2-digit common-cathode 7-segment LED displays

Other

J1	26-way IDC male connector
SW1,17	Key switches
PCB	PCB board of the display and keyboard

A burst fire power controller

Bart Trepak looks at another power control application for the PIC microcontroller

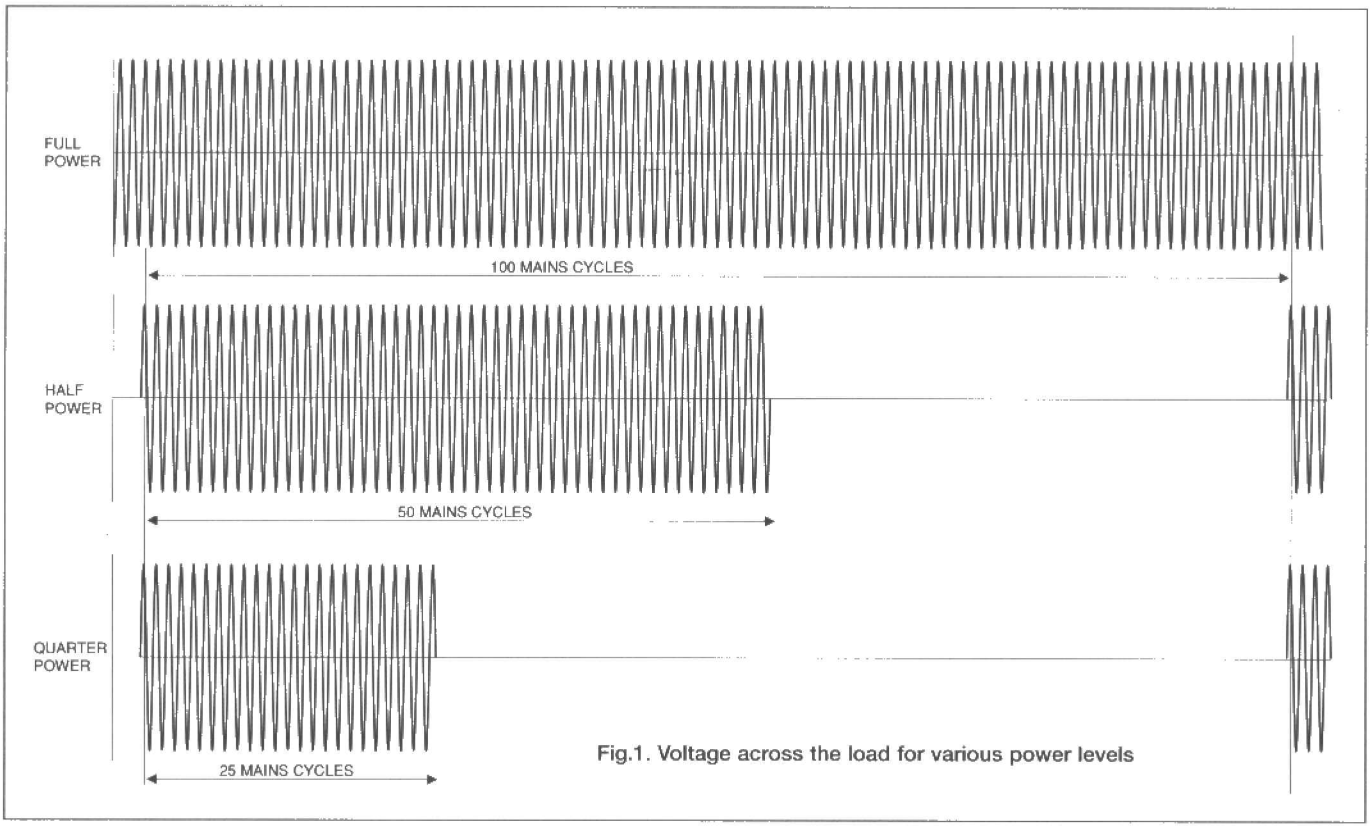


Fig.1. Voltage across the load for various power levels

Of the two methods of power control using triacs described in the last article, the Phase control method is by far the more responsive and accurate. This operates by switching the triac on for a longer or shorter portion of a mains half-cycle depending on the amount of power required. If such a system were used to control the power to a heater (to keep the temperature in a room at a constant value for example), then any sudden drop or rise in temperature could be compensated for during the next mains half-cycle by switching the triac on slightly earlier or later than in the preceding one, resulting in a fast response to changes in temperature. However, this method of power control has a serious drawback in that it generates large amounts of radio frequency interference caused by the fast switching of the triac. This requires the use of bulky and expensive components - normally chokes and capacitors and sometimes even shielding - to prevent the unit from acting as an effective radio transmitter causing interference to more useful transmissions. The cost and difficulty in achieving this increases as the power to be controlled is increased so that this method is used mainly for low powers (of up to a few hundred watts) and for lighting and speed control of motors where other methods are unsuitable.

For this reason, the zero voltage switching technique is used to control even low power heaters and in this method, the triac is allowed to switch the mains to the load only at the zero crossing points which totally eliminates radio interference. In this case, power control is achieved by allowing the triac to conduct for a varying number of mains cycles in a given period, depending on the power level required. This method of power control is called Burst Fire control as the triac is switched on in bursts. Fig. 1 shows the general idea. Thus, if only half power is required, the triac would be switched on for, say, 50 out of every 100 mains cycles. This would enable the power to be varied in 100 steps from passing 1 cycle in every 100 to 100 cycles in every 100. Finer control could be achieved by making the time base 1,000 or even 10,000

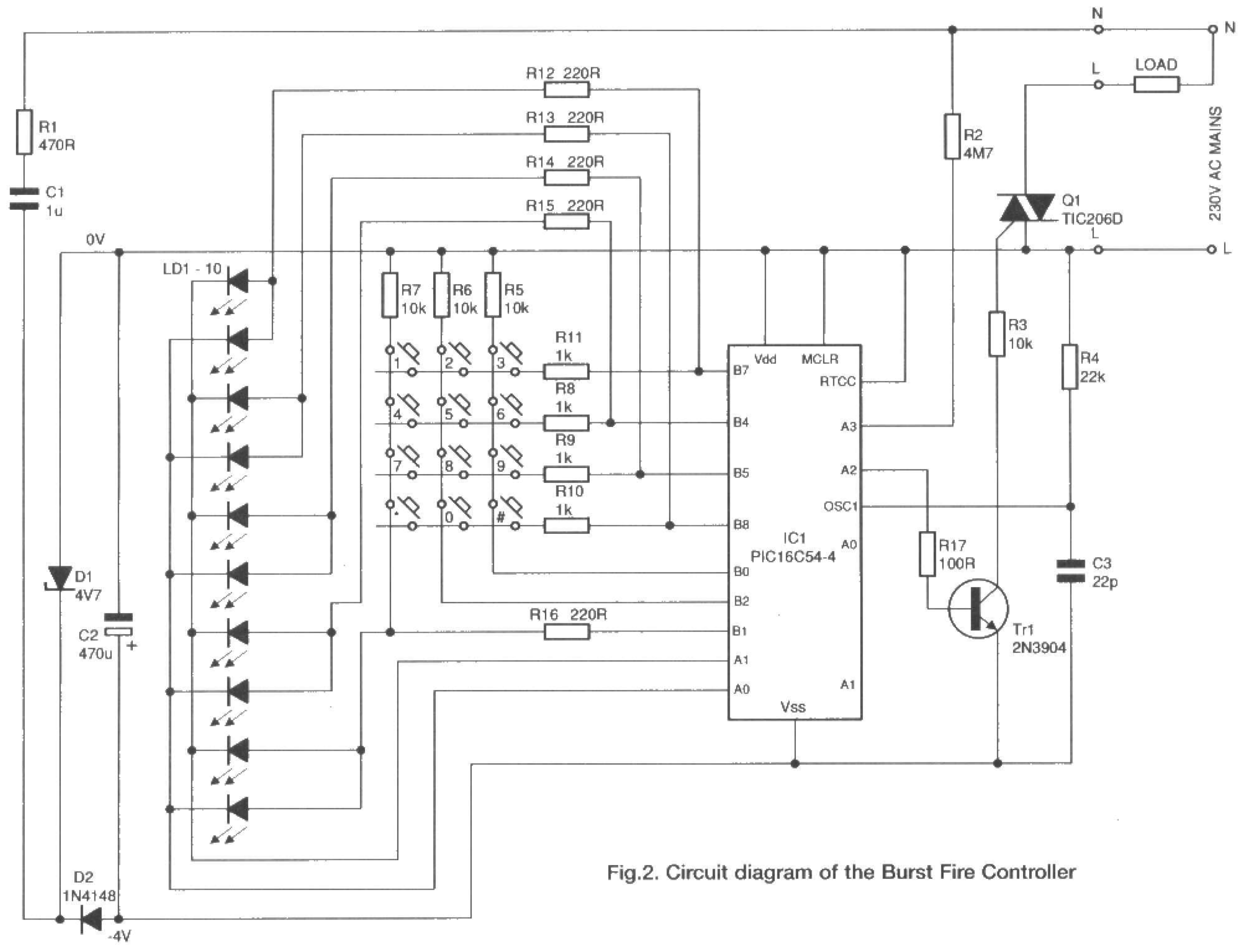


Fig.2. Circuit diagram of the Burst Fire Controller

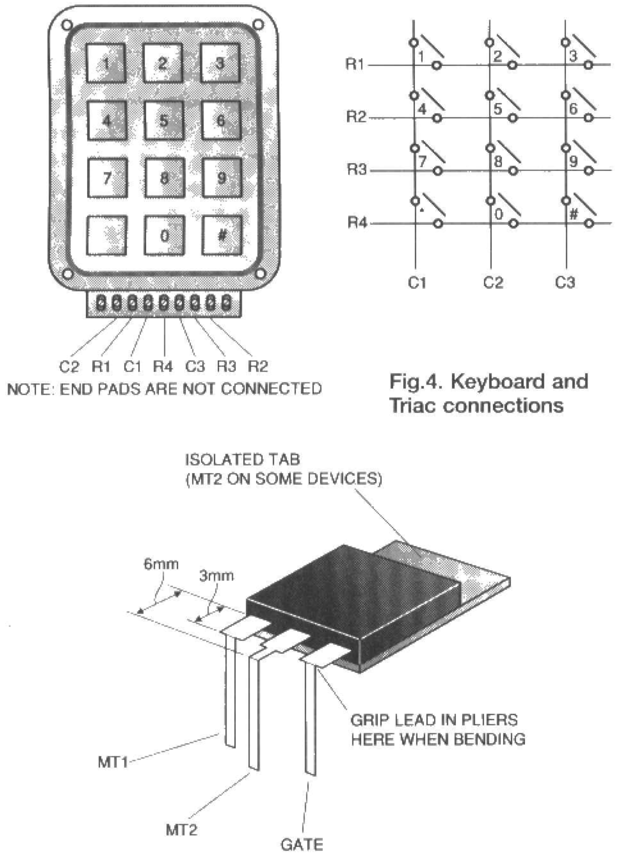


Fig.4. Keyboard and Triac connections

cycles long, giving control in 1,000 or 10,000 discrete steps.

However, there is a problem with this. At 50 Hz, 100 cycles would occur in two seconds but 1,000 and 10,000 would require 20 and 200 seconds (or over three minutes) respectively so that, to go back to our room heater example, if the temperature dropped for some reason, the controller would not be able to compensate until the next period which could be up to three minutes later. Your granny sitting in front of her three-bar electric heater would not be much impressed by the fact that the power was being controlled to one part in ten thousand if the heater remained at a low output for three minutes when you opened the door. Even without this, the temperature of the elements would rise and fall noticeably during the "on" and "off" periods and while, in practice, the temperature of a room may not change noticeably in three minutes (any change would tend to be localised unless there was a draught), such a situation could be disastrous in an incubator or a plastics moulding machine. A compromise must therefore be made between the speed of response and the degree of control which can be achieved. This will depend on the thermal inertia of the system so that if granny's heater takes a minute to heat up anyway, little would be gained by controlling the power every two seconds and 20 seconds would give a finer control without any apparent delay in the response to sudden temperature fluctuations.

For most "light" loads, (even electric bar heaters) the thermal time constant is considerably less than one minute and can usually be measured in tens of seconds and nobody would want to be able to control a room heater to better than 100 steps anyway. Indeed, many heaters usually only have two

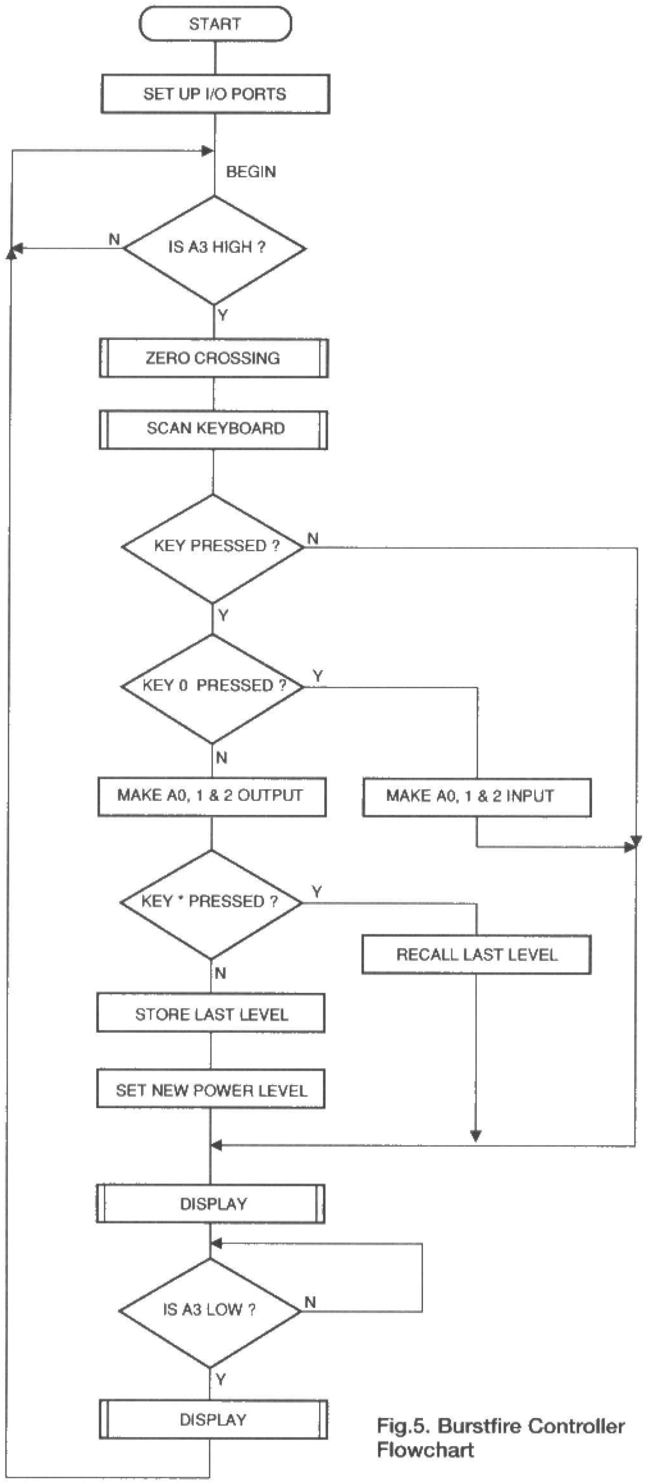


Fig.5. Burstfire Controller Flowchart

settings - high and low - so 100 steps would be more than adequate for this and most common applications. The above scenario implies that the controller has some sort of temperature sensor to enable it to respond to variations in temperature but the circuit to be described does not have this feature, being intended solely as a means of setting the power to a heating element. The setting is selected from a keypad which has ten digits (0-9) and two other keys and the circuit is based on the PIC micro-controller described in the preceding article.

Display

Since it would not be immediately obvious to the user which power level had been selected, the chip has been programmed to include a "bar graph" type of display of the current setting on ten LEDs. It would have been just as easy to programme the PIC to drive a seven-segment display to show the setting digitally but the method chosen was considered more suitable.

The LEDs are programmed to display the number of the key which was last pressed so that if key 5 had been entered for example, the fifth LED would light and the triac would supply half power by conducting for half of the 100 cycle period. The LED drive is multiplexed with the actual LED which is to light defined by the logic levels on port B and lines A0 and A1 of port A. This enables the display to share the same lines as the keyboard saving I/O lines and permitting the whole design to be based on a single chip. To light a particular LED therefore, port B is made an output as are lines A0 and A1. A logic 1 is then written to the appropriate port B output and then either line A0 or A1 is taken low.

It should be noted that this unit is not suitable for use as a lamp dimmer as the Burst Fire mode of operation would cause the lights to flash on and off unacceptably. A unit suitable for this using Phase control will be featured in a forthcoming article.

The circuit is also unsuitable for use with a fan heater because here it would cause the fan motor to vary in speed continuously in bursts as the triac was switched on and off. In this case, it may be possible to control the power to the heating element only while leaving the motor to run at full speed but whether this can be done easily in any given fan heater would depend on the particular model concerned. Some models use a low voltage motor and rely on the resistance of the heating element, which is connected in series, to "drop" the mains voltage. These would be unsuitable unless some other arrangement were made for reducing the voltage to the motor to its rated value. Any tampering or re-wiring of a heater would no doubt invalidate the warranty anyway.

Circuit diagram

The circuit shown in fig. 2 is, as many readers will no doubt have discovered with many PIC projects published in the past, a very simple affair consisting of little more than the micro-controller, keyboard, triac, and a few resistors. The clever stuff is all done in the chip by software.

DC power for the unit is derived from the mains by a "capacitor mains dropper" C1 and the voltage clamped to 4.7 Volts by the zener diode D1. D2 rectifies the resulting waveform which is smoothed by C2 to provide a nominal - 4 Volt supply. Since the unit is designed to switch the triac at the mains zero crossing, the mains signal is applied to one of the input ports via resistor R3 while the triac is triggered via output port A3.

The triac specified is an 8 Amp device enabling powers of up to 2 KW to be controlled provided the device is mounted on a suitable heatsink. This is quite easy to arrange because the triac specified has an isolated tab allowing it to be bolted to the heatsink without the need for insulating washers.

To ensure minimum radio interference, d.c. or continuous triggering is employed. Although an 8 Amp triac is specified, 16 Amp or even 25 Amp devices could be used for 3.5KW or 6KW loads but as the specified trigger current for these devices may be rather high for the PIC output to supply directly, a transistor driver has been included in the triac gate circuit. Even so, the current drawn from the supply when the triac is triggered causes the supply voltage to the chip to drop,

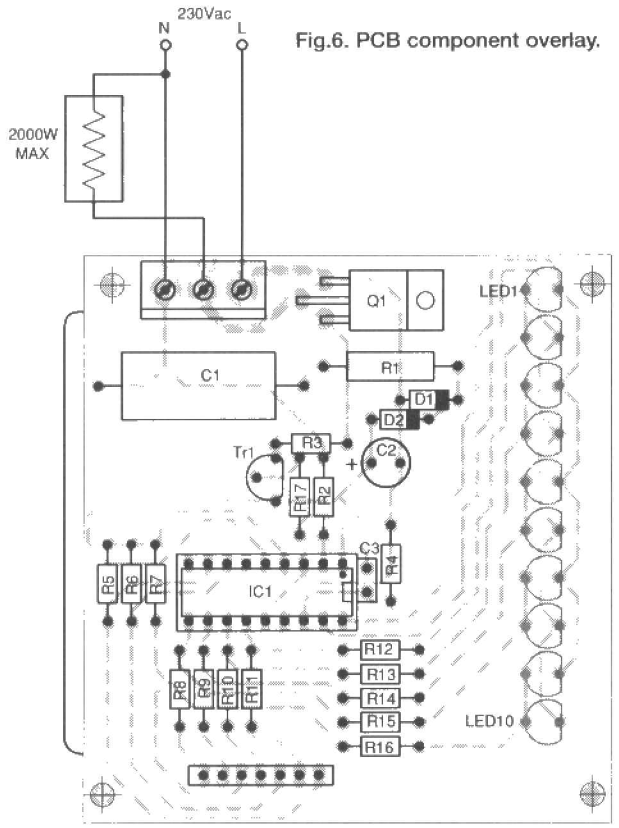


Fig.6. PCB component overlay.

KEYBOARD AND LEDs ARE MOUNTED ON THE TRACKSIDE

resulting in the LEDs dimming slightly. This is not a great problem and indeed it has the advantage that it shows that the controller is actually doing something (changing the ratio of the triac on to off time) which may not otherwise be readily apparent.

The keyboard and LED display is connected to port B of the micro-controller which divides its time between scanning the keyboard and driving the display which is multiplexed with the aid of two further outputs on port A enabling the 10 LEDs to be switched on as required. Because the display is shared with the keyboard, it is important to ensure that pressing a key will not upset the display by spuriously lighting unwanted LEDs and for this reason, 1kohm resistors are included in series with the switches. I/O port line B3 is not used and this is programmed as an output and should be left disconnected.

Construction

A suitable printed circuit board layout is given in the foils section at the end of this issue; the diagram in fig.6 shows the position of the components on the board. The sequence of assembly is not important but it is usually better to insert and solder the low profile components such as resistors and diodes first before proceeding to the taller components such as capacitors. Be careful to insert diodes and electrolytic capacitors the correct way around and pay particular attention to the orientation of the IC. In practice it is best to mount an 18-pin IC socket first and only plug in the IC after the unit has first been powered up and the polarity of the supply has been checked.

Depending on the load power to be controlled, the triac may need to be mounted on a suitable heatsink. Below about 300 Watts, no heatsink will be required but above this value, the triac should be bolted to a suitably dimensioned piece of aluminium or a commercially available finned heatsink. The triac may also need to be isolated from the heatsink with a mica or similar washer if MT2 is internally connected to the heatsink tab. This will not be necessary with the triac specified as on this, the tab is isolated from the triac chip. If a heatsink is used, it will of course, not be possible to mount the triac on the printed circuit board and the leads will need to be connected to the appropriate points on the PCB with suitable insulated wire. Note that since the current flowing in the wires connected to MT1 and MT2 could be as high as 25 Amps, it would be better to connect these wires directly to the points L and Lo on the terminal block or output socket (if used) and not rely on the PCB tracks. The triac connections are shown in fig. 4.

The keyboard should be mounted "back to back" with the main printed circuit board to form a single module which can then be mounted onto a panel after a suitable cut out has been made for the keyboard and LEDs. If the keyboard specified is used, this is best done by first soldering seven fairly stiff wires such as discarded resistor leads to the copper side of the main PCB. The keyboard may then be mated with the PCB ensuring that each wire is inserted into a corresponding hole in the keyboard after which they can be soldered to the pads on the keyboard. (Note that the keyboard has, in fact, nine holes but the two outer ones are not connected). It may be better to leave the wires somewhat longer to begin with to provide access to the track side of the PCB in case some re-soldering is required. The solder joints at the keyboard can then be re-melted and the PCBs pushed closer together once the unit has been tested and found to be working correctly.

Other keyboards with different connections may of course be used as long as they are "matrix" types and the connections to the printed circuit board are transposed to conform with the circuit. The connections for the keyboard used in the prototype are given in fig. 4 to enable this to be done if the keyboard used is not available.

The LEDs are also mounted on the track side of the printed circuit board and care should be taken to ensure that they are all soldered at the same height above the board and are all in a straight line. This can be most easily done by placing a piece of card about 3 to 5mm wide between the LED leads to define the height above the board and soldering one of the leads. When all the LEDs have been mounted, gently bend the LEDs into line before soldering the other leads, taking care not to bridge any of the tracks with solder. The LED leads may then be trimmed by cutting them flush with the surface of the component side of the board.

Subroutines

Before the unit is tested, it may be worthwhile to look at how the software is organised and a flowchart of the programme is shown in fig. 5. From this it can be seen that the main programme which begins at the label BEGIN continually tests input A3 to see if the zero crossing point has occurred. Depending on the result of this test calls the various subroutines which then deal with interrogating the keyboard, driving the LEDs or triggering the triac etc.

The zero crossing routine (called ZRX), which is called each time that the mains signal crosses zero at the beginning of the positive half cycle, decides if the triac still has to be triggered and also decrements the CYLCTR (cycle counter) which counts down the 100 mains cycles in each period. At the same time the PWRCTR (power counter) is also decremented and this switches off the triac drive when the required number of cycles have been counted. When the ZRX routine during which the CYLCTR counter reaches zero is called, the CYLCTR is reloaded with 100 while the PWRCTR counter is loaded with the value stored in the PWRREG (power register). This defines the number of cycles for which the triac will conduct, and the triac is switched on.

The SCAN subroutine deals with reading the keyboard and returns from the subroutine with a number corresponding to the key pressed in the W register. which, if it is not key 0 or * is loaded into the PWRREG. If no key is pressed, the number in the W register is zero, enabling the programme to test for this easily and take no further action, bypassing the next section of the programme and going on to the DISPLAY routine. If a key has been pressed, the programme checks to see if it was key 0, in which case output ports A0, A1 and A2 are made inputs which switches off the triac and LEDs giving a zero power level (off). If it was not key 0, A0, A1 and A2 are made outputs and the programme checks if the key pressed was the * key. This key has a "recall" function and loads the PWRREG register with the previous value which was set. If one of the numbered keys is pressed however, the current value in the PWRREG register is saved (for later recall if required) and the new value is loaded into the PWRREG to give a new power level. Key # causes the PWRREG to be loaded with 100 which results in continuous triac conduction and therefore full power. The keyboard is read once per mains cycle and no key debounce routine is used as each key performs only one function irrespective of how many times it is pressed or the contacts bounce. If key 3 is pressed for example, the relevant registers are loaded with a suitable value to give 30% power and if it is pressed again or bounces, no new action will take place.

Not surprisingly, the subroutine which displays the resulting power level on the LEDs is called DISPLY. This operates as a look-up table by taking the value in the PWRREG and obtaining a value from the table CONVRT which enables the correct LED to be lit by setting the appropriate bit in port B high and either A0 or A1 low. A DELAY subroutine is then called to energise the LED for a few milliseconds before it is switched off in time for the next zero crossing. While the other subroutines are called only after the positive zero crossing, the DISPLY routine is called after the positive and negative zero crossing which means that the LED is switched on 50 times per second - is fast enough to give a continuous display without appearing to flicker. Before the main programme is entered, following a reset which occurs when power is first applied, the programme jumps to the label START and follows a SETUP routine which defines the input and output ports and sets the initial condition of the controller to off after which the main programme is entered at the label BEGIN.

TESTING

REMEMBER THAT THIS UNIT OPERATES AT MAINS VOLTAGE WHICH CAN BE DANGEROUS. SWITCH OFF ALL SUPPLIES AND DISCONNECT THE UNIT BEFORE ATTEMPTING ANY SOLDERING OR ADJUSTMENTS. DO NOT EARTH ANY PART OF THE CIRCUIT AS DAMAGE TO COMPONENTS WILL OCCUR. DO NOT TOUCH ANY PART OF THE CIRCUIT WHEN IT IS CONNECTED TO THE MAINS AS THIS COULD BE A SHOCKING AND POSSIBLY FATAL EXPERIENCE.

Testing of the unit is best carried out on the bench with a small lamp in place of a heater. Since the triac is d.c. triggered, it will work quite happily with loads down to 15W or less without any problems with latching. To avoid damage and blown fuses in case of mistakes, it is a good idea to connect a lamp of, say, 150W temporarily in series with the L lead of the mains supply to act as a current limit. Connect the unit to the mains supply with a small lamp connected to the output (between Lo and N) to act as a load as shown in Fig. 7 and switch on. With a voltmeter set to 10V d.c. range, measure the voltage between pins 5 and 14 of the IC holder which should show a reading of approximately 4 Volts (pin 5 negative). Provided that this voltage is not greater than 5 Volts, switch off the supply and plug in the microcontroller chip making sure that it is inserted the correct way around. The PIC is a CMOS device and although it has got built in protection against static damage, it should still be handled carefully taking all the usual precautions. To ensure a good reset, it is a good idea to short out the supply smoothing capacitor C2 before inserting the chip into the circuit following this test because without the IC in the circuit, there is no discharge path for C2. With the chip now in circuit, switch on the mains supply and the unit should remain off with all LEDs and the lamps extinguished. Pressing each key 1 to 9 in turn should result in the corresponding LED being lit and the lamp simulating the load should switch on and off, staying on for longer periods for the higher numbers. Pressing the # key will light the topmost LED and the load lamp will stay on permanently resulting in full power. The unit may be switched off by pressing the 0 key which will result in the lamp and all the LEDs switching off. The 150W lamp (if fitted) should remain off except perhaps for a slight glow if a 40W lamp is used as the temporary load.

PARTS LIST

Resistors

R1	470R 1/2 Watt
R2	4M7
R3	10k
R4	22k
R5-R7	10k
R8-R11	1k
R12-R16	220R
R17	100R

Capacitors

C1	1uF/400V
C2	470uF/16V Radial
C3	22pF Ceramic

Semiconductors

D1	4V7 Zener diode
D2	1N4148 diode
LD1-LD10	5mm LEDs
TR1	2N3904 NPN
Q1	TIC206D Triac (see Text)
IC1	PIC16C54-4 (programmed)

Misc

PCB
12-way keyboard (matrix type)
18-pin dil socket
3-way terminal block.

Programmed PIC chips area available from the author price £12.50. Orders should be sent to:

Bart Trepak, 11 Studland Road, London W7 3QU.

Please allow up to 28days for delivery

As mentioned, the * key, when pressed should recall the previous power setting.

No adjustments are required and if the circuit operates as described then it is ready for use.

No details are given for mounting the unit as much will depend on personal preference and the purpose for which it will be used. The size of the enclosure will depend on the power to be controlled as this will determine the size of any heatsink which may be required. In any event, it should be mounted, preferably in a plastic box, or if higher powers are to be controlled, a metal box which should be earthed, and the normal precautions taken when dealing with mains powered equipment. A suitably rated fuse should also be fitted into the Live lead and a panel mounted fuse holder mounted on the box would probably be best for this purpose. Note that when the load is switched off by pressing key 0, the circuit is still powered and a separate ON/OFF switch (suitably rated for the expected load current) should also be fitted to the finished unit.

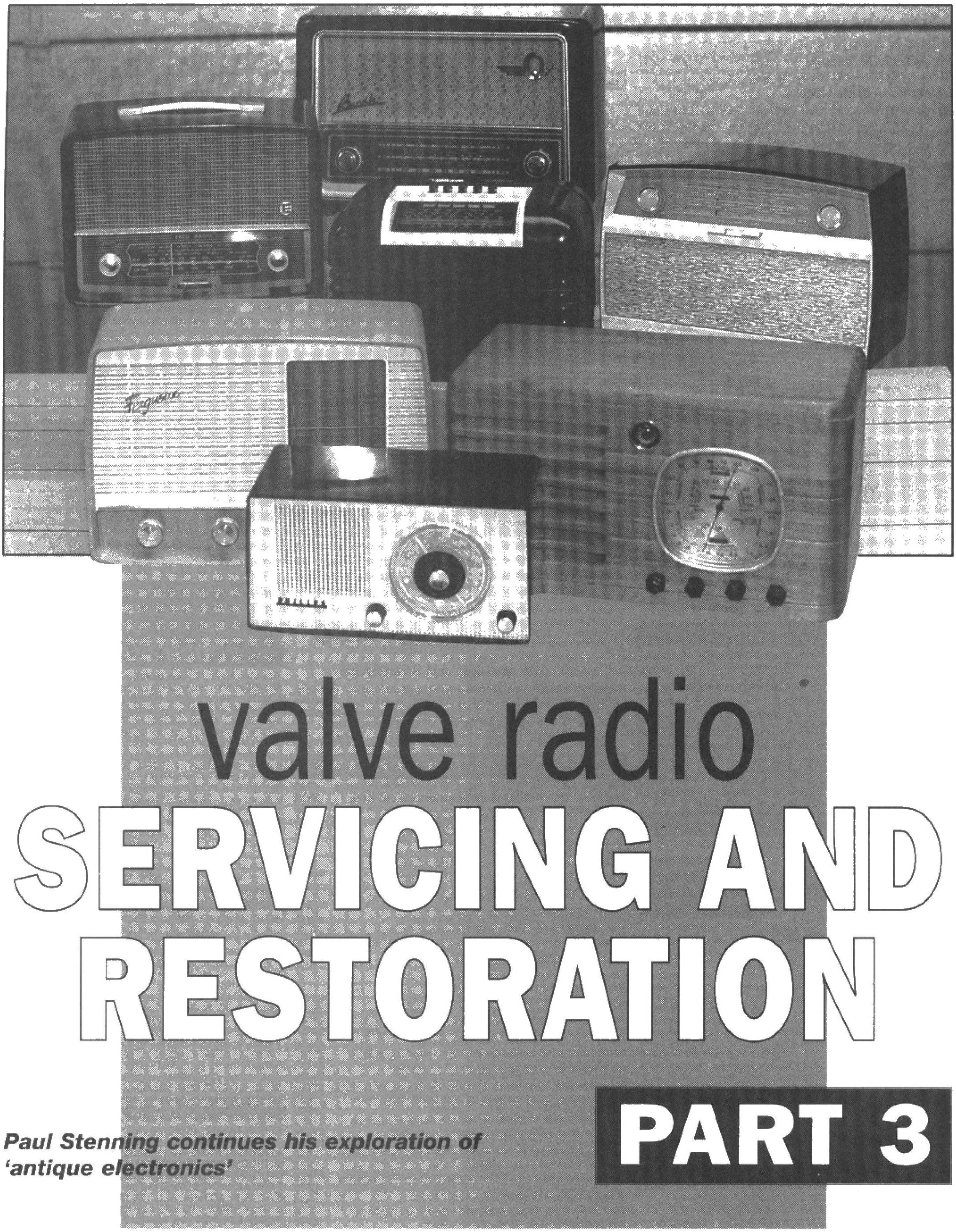
If the unit is to be used to control the power to various heaters, the unit could be mounted in any conveniently sized plastic box fitted with a 13 Amp socket with a suitably shaped cut out to accept the keyboard and LEDs together with a fuse and ON/OFF switch. The ability of the unit to control "low power" loads would make it ideal for controlling the power to soldering iron enabling the temperature of a 25 or 40W iron to be reduced when soldering sensitive components such as surface mounted devices or when the iron was on stand-by. Full power or any other level may then be selected simply by pressing the recall key (*) or required push button.

Assembler listing

```
;KBURST.ASM   BURST FIRE CONTROLLER WITH DISPLAY
;************************************************
;
LKP      equ 08h ; Last Key Pressed
DYCTR1   equ 09h ; DelaY CounTeR1
DYCTR2   equ 0Ah ; DelaY CounTeR2
DYCTR3   equ 0Bh ; DelaY CounTeR3
TEMP     equ 0Ch ; TEMPorary register holds display
for port B
CYLCTR   equ 0Dh ; CYcLe CounTeR - counts 100
cycles
PWRCTR   equ 0Eh ; PoWeR CounTeR - counts number of
cycles triac is on
PWRREG   equ 0Fh ; PoWeR REGister - holds power
level required
DSPLY    equ 10h ; DiSPLaY register - holds
FLAG     equ 11h ; FLAG register F0- key already
pressed
CPLREG   equ 12h ; Current Power Level REGister
                ;
         LIST P=16C54
         include "PIC.h"
;************************************************
;
         goto START
;************************************************
;
ZRX      clrwdt   ;***ZERO CROSSING SUBROUTINE***
                ;
         bsf PORTA,0       ; TEMP
         decfsz CYLCTR,1
         goto ZRXA         ; cycle counter not zero
         movlw .100
         movwf CYLCTR      ; load cycle counter with
100 if it is zero
         bsf PORTA,2       ; SWITCH TRIAC ON ?
         movf PWRREG,w
         movwf PWRCTR      ; load Power counter from
power register
                ;
ZRXA     movf PWRCTR,1
         btfsc STATUS,2   ; is PWRCTR = 0?
         goto ZRXB         ; yes - ON period is over
         decf PWRCTR,1    ; no
                ;
         movf PWRCTR,w    ; decimal adjust******
         andlw 0Fh         ; and with 0000 1111 to
mask MSnibble
         xorlw 0Fh         ; compare to 0Fh ie has
lsd underrun?
         btfss STATUS,2
         goto ZRXEND       ; no
         movlw 06h         ; yes - subtract 6
         subwf PWRCTR,1
         goto ZRXEND
                ;
ZRXB     bcf PORTA,2       ; SWITCH TRIAC OFF  ?
                ;
ZRXEND   nop      ;  bcf PORTA,0
         retlw 00
                ;
;************************************************
;***DISPLAY SUBROUTINE***
DISPLY   movlw 00h
         tris PORTB        ; make port B an o/p
         clrf PORTB
         swapf PWRREG,w   ; swap and place in w
register
         andlw 0Fh         ; mask top four bits ie.
0000 1111
         movwf TEMP
         btfss TEMP,0      ; check if PWRREG odd or
even
         goto EVEN         ; even
         bcf PORTA,0       ; odd - switch on A0
CVT      call CNVRT        ; call look-up table
         movwf PORTB       ; output to port B
         call DELAY
         bsf PORTA,0       ; switch off led drive A0
         bsf PORTA,1       ; and A1
         retlw 00
                ;
EVEN     bcf PORTA,1
         goto CVT
;************************************************
;***CONVERT SUBROUTINE***
CNVRT    addwf PC          ; add w to programme
counter
         retlw 00h
         retlw 01h         ; show 10
         retlw 01h         ; show 20
         retlw 10h         ; show 30
         retlw 10h         ; show 40
         retlw 20h         ; show 50
         retlw 20h         ; show 60
         retlw 40h         ; show 70
         retlw 40h         ; show 80
         retlw 80h         ; show 90
         retlw 80h         ; show 100
                ;
;************************************************
;***DELAY SUBROUTINE***
DELAY    movlw 01
         movwf DYCTR2
D2       movlw 0FFh
         movwf DYCTR1
D1       decfsz DYCTR1,1
         goto D1
         decfsz DYCTR2,1
         goto D2
         retlw 00h
                ;
;************************************************
;
SCAN     clrwdt   ;***KEYBOARD SCAN SUBROUTINE***
         movlw 07h         ; ie. 0000 0111
         tris PORTB        ; make port B0-B2 i/ps
and B3-B7 o/ps
         movlw 0FFh        ; ie. 1111 1111
         movwf PORTB       ; make all o/ps high
                ;
         bcf PORTB,4       ; make B4 low
         nop
```

```
        btfss PORTB,0       ; B0 low?
        retlw 60h           ; yes - KEY6 pressed
        btfss PORTB,1       ; B1 low?
        retlw 40h           ; yes - KEY4 pressed
        btfss PORTB,2       ; B2 low?
        retlw 50h           ; yes - KEY5 pressed
        bsf PORTB,4         ; no keys pressed - make
B4 high
                ;
        bcf PORTB,5         ; make B5 low
        nop
        btfss PORTB,0       ; B0 low?
        retlw 90h           ; yes - KEY9 pressed -
return with 1001 0000
        btfss PORTB,1       ; B1 low?
        retlw 70h           ; yes - KEY7 pressed -
return with 0111 0000
        btfss PORTB,2       ; B2 low?
        retlw 80h           ; yes - KEY8 pressed -
return with 1000 0000
        bsf PORTB,5         ; no keys pressed - make
B5 high
                ;
        bcf PORTB,6         ; make B6 low
        nop
        btfss PORTB,0       ; B0 low?
        retlw 0A0h          ; yes - KEY# pressed -
return with 100 BCD
        btfss PORTB,1       ; B1 low?
        retlw 0B0h          ; yes - KEY* pressed -
return with 1011 0000
        btfss PORTB,2       ; B2 low?
        retlw 0C0h          ; yes - KEY0 pressed
return with 1100 0000
        bsf PORTB,6         ; no keys pressed - make
B6 high
                ;
        bcf PORTB,7         ; make B7 low
        nop
        btfss PORTB,0       ; B0 low?
        retlw 30h           ; yes - KEY3 pressed
        btfss PORTB,1       ; B1 low?
        retlw 10h           ; yes - KEY1 pressed
        btfss PORTB,2       ; B2 low?
        retlw 20h           ; yes - KEY2 pressed
        bsf PORTB,7         ; no keys pressed - make
B7 high
                ;
        retlw 00            ; no keys pressed
                ;
;*************************************************
;
START   nop
                ;
SETUP   movlw 1Fh           ; ie. 0001 1111
        tris PORTA          ; make portA i/p - triac
off
        movlw 0FBh          ; ie. 1111 1011
        movwf PORTA
                ;
        movlw 00h
        movwf PWRREG
        movwf CPLREG
```

```
clrf FLAG
                ;
BEGIN   btfss PORTA,3       ; is A3 = 1 ie. zero
crossing
        goto BEGIN          ; no
        call ZRX            ; yes
        clrf LKP
        call SCAN
        movwf LKP           ; place returned key code
into LKP
        movf LKP,1
        btfsc STATUS,2      ; LKP=0 if no key pressed
ie. is key pressed?
        goto NOKEY          ; no
                ;
        btfsc FLAG,0        ; first time?
        goto LOOP           ; no
        bsf FLAG,0          ; yes - first time key
pressed - set flag0
        movlw 0C0h          ; yes, a key is pressed
first time
        xorwf LKP,w         ; KEY 0?
        btfsc STATUS,2
        goto SWTOFF         ; yes - switch off
        movlw 18h           ; no    i.e 0001 1000
?
        tris PORTA          ; switch triac o/p on
        movlw 0B0h
        xorwf LKP,w         ; KEY *?
        btfsc STATUS,2
        goto RECAL          ; yes - recall previous
power setting
        movf PWRREG,w       ; no - save current power
level
        movwf CPLREG        ; in CPLREG
        movf LKP,w          ; power level selected by
key pressed
        movwf PWRREG        ; store in PWRREG
        movlw 01h
        movwf CYLCTR        ; make cycle counter = 1
        goto LOOP
                ;
RECAL   movf CPLREG,w       ; reload PWRREG
        movwf PWRREG        ; with contents of CPLREG
        goto LOOP
                ;
SWTOFF  movlw 1Fh           ; switch o/p off ie. 0001
1111
        tris PORTA          ; make A2 an i/p
                ;
NOKEY   bcf FLAG,0          ; clear flag0
LOOP    call DISPLY
LOOPA   btfsc PORTA,3       ; is A3 = 0? ie. zero
crossing
        goto LOOPA          ; no
        call DISPLY         ; yes
        goto BEGIN
                ;
;*************************************************
org 1FFh
        END
```



valve radio SERVICING AND RESTORATION

PART 3

Paul Stenning continues his exploration of 'antique electronics'

Most sets will have a Class A output stage, with a single valve driving the output transformer. In the Bush circuit, V7 (EL84) is the output valve, driving transformer T1. The anode current is generally between 25 and 40mA. This passes through the primary of the output transformer, which will drop typically 15 to 25V. If this voltage drop is present, it confirms that the valve is drawing anode current.

The output valve is usually biased by means of a cathode biasing resistor. The biasing level is dependent on the valve type used, and can be obtained from the service sheet or valve data book.

Output stage faults

A very common fault is a leaky grid coupling capacitor (C56). This causes the control grid to be at a potential above 0V, which alters the biasing of the valve causing it to draw excessive current. If the problem is ignored, it will get progressively worse until the valve fails, often destroying the output transformer in the process. Be sure to check this point even if the set appears to be working correctly.

The voltage on the grid can be measured directly with a digital meter, and should be virtually zero. If you have an analogue meter you will have to measure the voltage across the cathode resistor and compare this with the value on the service sheet.

Internal leakage within the valve can cause a similar situation to occur. This is less common than a leaky capacitor, but it does occur particularly in later AC/DC sets due to the high operating temperatures. If a replacement capacitor does not help, you need a new valve.

Output transformer

The output transformer is prone to failure, in the form of the primary going open-circuit. This will result in a silent set, with a high HT voltage. Since the output valve has no load on its anode, the screen grid will act as an anode and can sometimes be seen as a hot spiral of wire glowing inside the valve.

The output valve sometimes fails at the same time as the transformer. It may be worth getting the valve tested, as a repeat performance is not desirable! Failure of the valve or output transformer often results in damage to the cathode resistor and bypass capacitor, so these should be replaced.

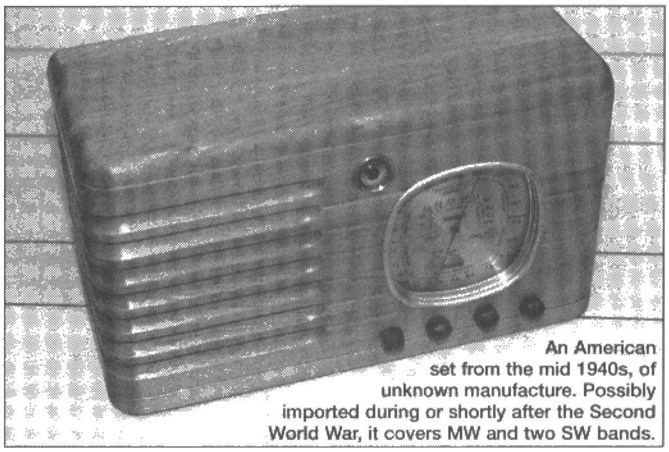
Because the output transformer carries a standing DC current, a conventional transformer (such as a mains or 100V line type) cannot be used. Any replacement transformer must be designed specifically for this purpose.

RS sell a suitable modern transformer (Stock Number 217-567, price £7.65), which has several tappings on the primary and secondary. The RS catalogue gives a table of primary and secondary impedances, and suitable tappings. This can be used in conjunction with the Ra or RL (external anode load impedance) figure in the valve data book to establish the correct connections. Often terminals 1 and 4 on the primary, and B and D on the secondary gives a suitable ratio for mains sets. For a battery set try terminals 1 and 4 on the primary, and A and C on the secondary. These connections are only a suggested starting point. Do not change the primary connections with the set switched on. This is a modern component and may well look out of place on a vintage chassis.

Valve radio dealers such as Anode Electronics may offer good used components from scrap sets. This would be more in keeping with the age of the set. I have used the output transformers from most of my scrap chassis to repair other sets. If all else fails, or you want to keep the original transformer, you may be able to get it rewound professionally.

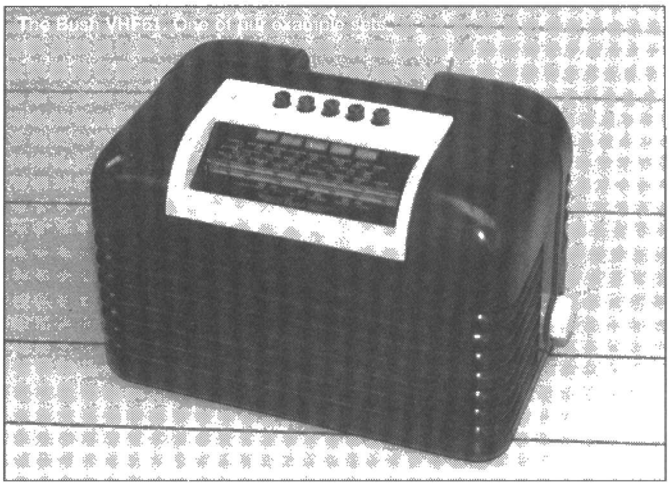
Alternative output biasing

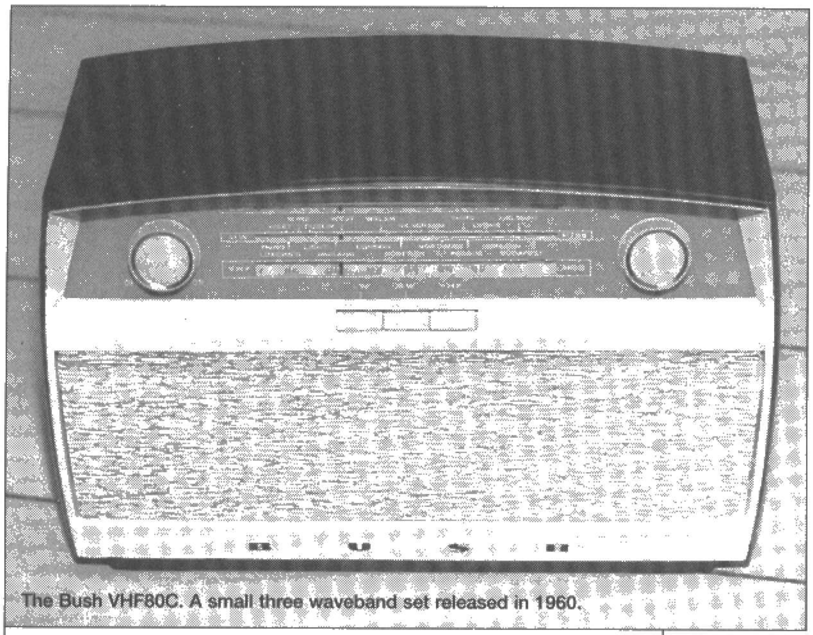
The Ekco set uses an alternative method of biasing the output valve. R13 and R14 are low value resistors and are placed in the 0V connection. The total HT current passes them, and they drop a few volts. The cathode of the output valve is connected directly to 0V, and the control grid is biased to the lower end of the resistors, thereby obtaining the negative bias.


An American set from the mid 1940s, of unknown manufacture. Possibly imported during or shortly after the Second World War, it covers MW and two SW bands.

The Ferguson 621U. A three waveband (VHF/MW/LW) set from the late 1950s, constructed on a PCB.

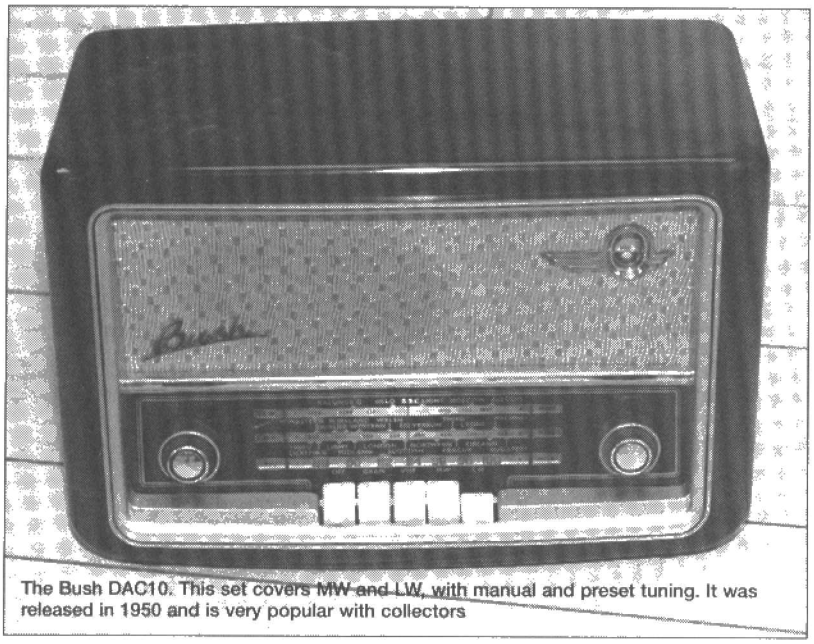
The Philips B2G81U. A small AC/DC set released in 1959, constructed on a printed circuit board.


The Bush VHF61. One of our example sets.



The Bush VHF80C. A small three waveband set released in 1960.

Above: The Ekco U245. One of our example circuits.



The Bush DAC10. This set covers MW and LW, with manual and preset tuning. It was released in 1950 and is very popular with collectors

From the service sheet, 3.8V is dropped across the resistors. This is less than the figure of 10.4V given in the valve data book for the UL41 valve used. The screen grid is connected to a lower than usual voltage, which reduces the anode current, compensating for the lower biasing voltage on the control grid.

Output stage variations

In some cases a small section of the output transformer primary winding is connected in series with the decoupling resistor feeding the remainder of the set. The purpose of this is to cancel out hum.

A few sets use a Class B push-pull output stage. This circuit has two output valves and a centre tapped output transformer. This arrangement is used on some battery sets to reduce current consumption. The two output pentodes are often contained in one valve. It is also used in some larger mains sets to give an increased power output and higher quality.

Audio pre-amplifier

The output stage is normally preceded by an extra stage of audio amplification. This is generally a triode circuit, and a single valve often contains this triode and the detector diodes. In the Ekco set this valve is V3 (UBC41), the upper anode being that of the triode, and the control grid being between this and the cathode.

The lower anodes, to either side of the cathode, are those of the detector and AGC diodes. In some economy sets the triode amplifier is incorporated into the output valve (UCL82 or similar), and the detector diodes are contained in the IF amplifier valve (UBF89 or similar).

This stage is normally reliable, although the anode resistor sometimes goes open-circuit or high in value. In some sets the anode supply is separately decoupled, and the decoupling resistor or capacitor may fail.

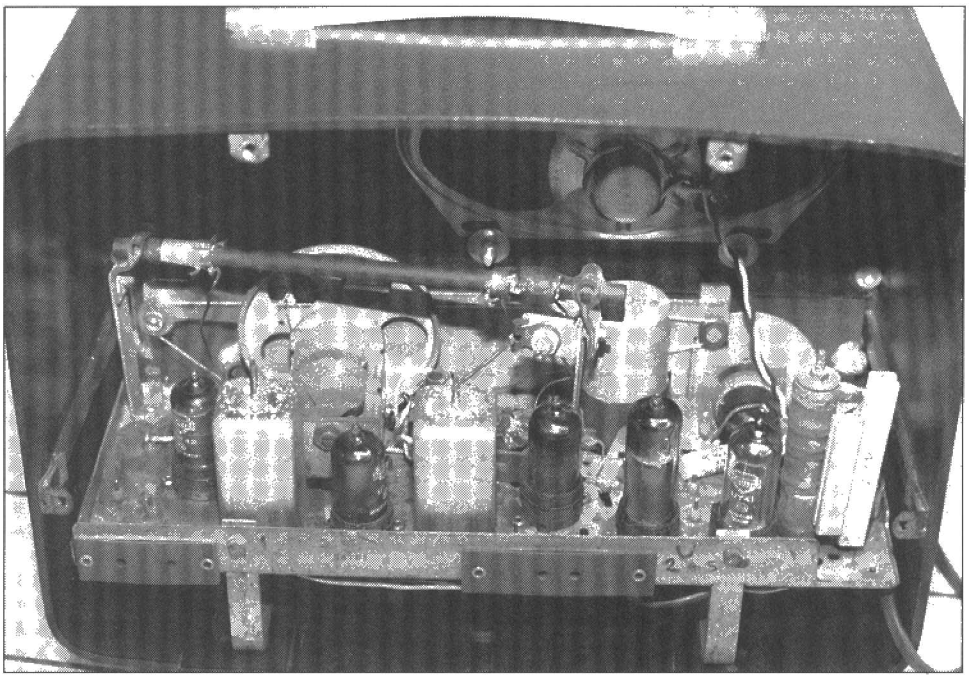
Tone control

Most sets have just a simple form of top-cut tone control. This is normally in the form of a capacitor and variable resistor in series, connected between the audio signal and 0V at a suitable point. In the Bush set VR2 and C54 are the tone control, and are positioned on the control grid of the output valve. Alternative positions are across the volume control on the input of the pre-amplifier valve, or around the output transformer.

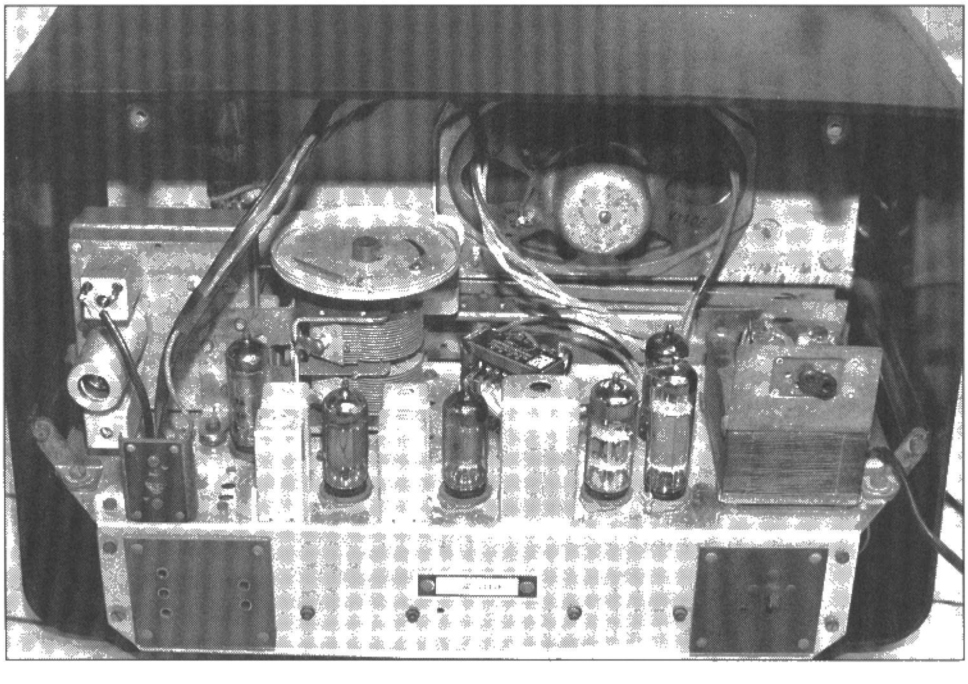
Noisy controls

Noisy and crackly tone and volume controls can often be fixed with contact cleaning fluid (such as Electrolube X2). Do NOT use WD40 for cleaning potentiometers as this will remove the resistive material.

If the cleaning fluid is not successful you will probably have to replace the whole control. Many volume control pots are 500K and include the mains switch. A 1M0 switched pot can be used if a



Right: An internal view of the Ekco U245 (one of our example sets). Note the additional resistors connected across the faulty dropper resistor to the right of the set.



An internal view of the Bush VHF61 (one of our example sets). The VHF tuner assembly is visible at the left of the chassis, next to the tuning capacitor. The mains transformer and voltage selector are on the right side. Below this on the rear of the chassis is the internal speaker switching screw and external speaker sockets. The tuning indicator is just visible on the speaker board to the left. Note that the output transformer (centre) is the RS replacement type suggested in the text.

The tetrode solves the capacitance problem allowing operation at high frequencies. If it were connected directly to 0V it would act as another control grid and greatly reduce the anode current. It is therefore often connected to the HT rail via a resistor to drop some voltage, and decoupled to 0V with a suitable capacitor.

1M0 resistor is connected in parallel with the track.

In some sets additional tone correction components are connected to a mid-point tapping on the pot track. Since this type of pot is no longer available the tone correction components may have to be omitted, unless a second-hand control is available.

In some later sets, two controls are incorporated into one component. These are no longer available, but you may be able to salvage something from a scrap set or obtain a second-hand component from a dealer. Alternatively, the control could be dismantled and the faulty pieces replaced with parts from other controls.

RF and IF stages

This discussion is based solely on superhet circuits. Earlier sets used TRF circuits, with reaction to increase the gain and selectivity. This type of circuit has been covered in detail recently in ETI.

AM Circuits

The MW, LW and SW dials of most valve radios will be marked in wavelengths (metres) rather than frequencies. To convert from one to the other, divide 300,000 by the known figure.

Thus 300,000 divided by 1215KHz gives 247 Metres. Conversely, 300,000 divided by 247 Metres gives 1215KHz. This confirms that "Virgin 1215" is received at the 247 Metre point on MW (the former position of the "Light Programme").

Local oscillator

In the Ekco set, L1 and L2 are the ferrite rod aerial. L2 is used on LW only, and is shorted out by S1 on MW. The aerial circuit is tuned by C6.

V1a (UCH42) is the local oscillator which is tuned by L5 to L8 and C10 to C17. C11 is ganged with C6, so the oscillator frequency varies as the tuning is adjusted. S2 and S3 are the wavechange switch.

V1b is the mixer stage (the type of combined valve used for

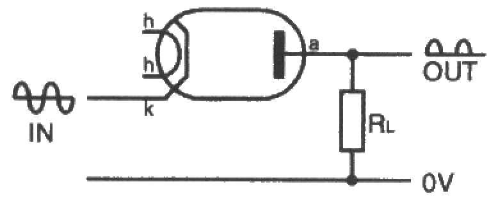


FIGURE 1 - DIODE RECTIFICATION

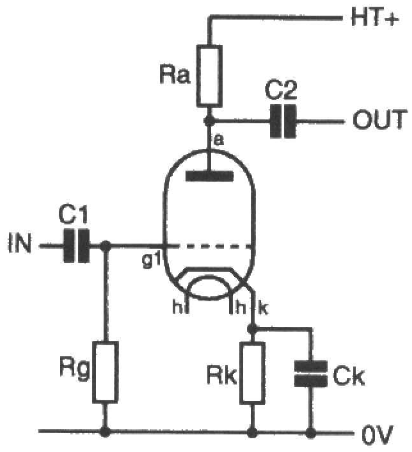


FIGURE 2 - TRIODE AMPLIFIER

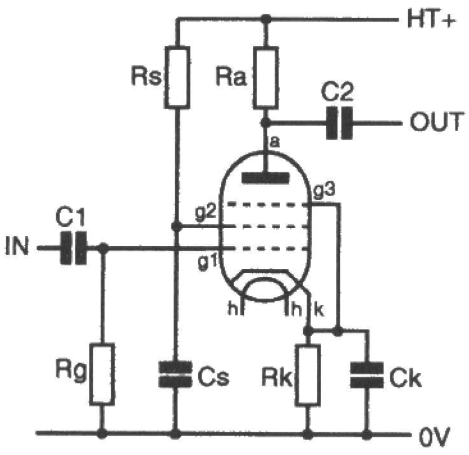


FIGURE 3 - PENTODE AMPLIFIER

V1 is often referred to as a "mixer-oscillator" or a "frequency changer"). The IF varies between different sets, but 470KHz is a common value. The service sheet for the set will give the frequency used, but you only need to know it if you intend to realign the set.

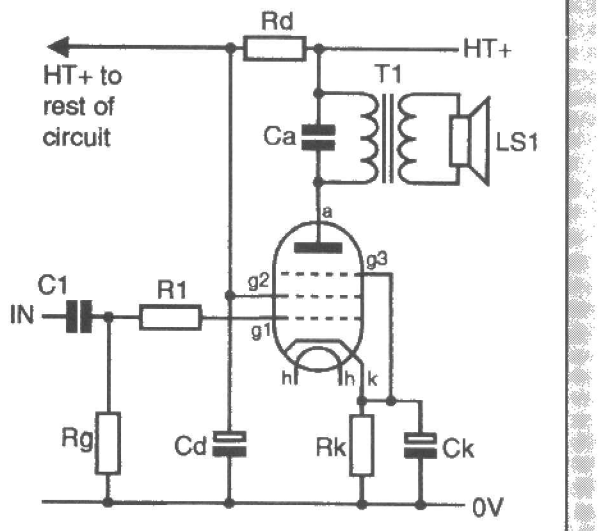


FIGURE 4 - PENTODE OUTPUT STAGE

If there is no reception, but noise is heard which alters in note and volume as the set is tuned across the band, the local oscillator is probably not working. Measure the voltage on the anode of the oscillator section. If the oscillator is running the voltage will be between about 50V and 100V; if it is faulty the voltage will be much lower. To confirm that the local oscillator is at fault, tune the receiver to a position on the dial where you would expect to receive a strong signal (such as a local station on MW). Connect a signal generator to the control grid of the mixer-oscillator valve, and tune the generator across a band of frequencies around 400KHz to 500KHz above the station frequency. This simulates the action of the local oscillator, and if the station is heard it proves that the local oscillator is indeed faulty.

IF amplification

In the Ekco set, the first IF transformer is L3/L4 which is tuned by C8 and C9. V2 (UF41) is the IF amplifier, which is followed by the second IF transformer L9/L10, tuned by C18 and C19.

Some higher cost receivers, and several Bush AM/FM sets, were fitted with two IF amplifier stages. In the Bush set, the AM IF transformers are IFT2, IFT4 and IFT6, and the IF amplifier stages are V3 and V4 (both EF89). V2 (ECH81) is the mixer-oscillator.

Voltage checks are the most useful method of checking the IF stages. The anode of the IF amplifier valve will be fairly high, generally above 150V. Applying the meter should give a crackle from the speaker if the following stages are in order.

The voltage on the screen grid varies with different designs, but anything below about 60V is cause for suspicion. The voltages on the mixer section of the mixer-oscillator should be similar to those mentioned above.

Note that the voltages given on the service sheets assume the use of an analogue meter. A digital meter has a much higher input impedance which will load the circuit less and may give higher readings.

AM detection and AGC

In the Ekco, the detector diode is contained in V3 (UBC41). The anode of the diode is shown to the left of the shared cathode, which is at the bottom centre. The IF is filtered by C20, leaving the audio signal present across the volume control (R7).

The AGC (Automatic Gain Control, also known as Automatic Volume Control - AVC) voltage is developed by the other diode in V3. The anode of this is shown to the right of the shared cathode. This is smoothed to an average DC level by R11 and C21.

The gain of V1a and V2 can be varied by altering the biasing voltage on the control grid. This sort of valve is sometimes referred to as vari-mu, and can be denoted by the diagonal arrow through the symbol. The AGC voltage is used to set the control grid biasing of V1a and V2.

The AGC voltage is at a high impedance, so any leakage in the decoupling capacitor (C21) will reduce the AGC level. This will give excessive gain for the signal level received, resulting in possible distortion and instability. It is normally worth replacing all the AGC decoupling capacitors if the set is prone to noise and whistles, or the performance does not seem right.

AM circuit variations

The majority of sets will have circuits similar to that outlined above. On sets having several wavebands and/or preset tuning, the circuit will appear to be more complex, due to the switching in the aerial and oscillator sections.

Earlier sets did not have ferrite rod aerials. Some used internal frame aerials, but the majority relied on an external aerial. This is connected via a socket on the rear of the set, similar to that on the Ekco. An earth socket is also provided, which is connected to the chassis. On AC/DC sets the aerial and earth sockets are connected via capacitors, to isolate them from mains voltages.

If you are repairing a set of this type, you will need to arrange a suitable aerial otherwise very little will be received. A three metre (ten foot) length of wire connected to the aerial socket will generally be adequate.

The Bush set, in common with most AM/FM sets, uses a single diode for detection and AGC. Many MW/LW sets also used a single diode for both functions, even though the valves contained two diodes. The two diodes were either used in parallel, or the anode of the unused diode was connected to the cathode.

In some higher quality sets there is an RF amplifier stage between the aerial and the mixer-oscillator. This is common on high quality SW receivers, and gives an improved signal-to-noise ratio on weak signals.

Common faults

On some sets the screen grid of the mixer-oscillator is driven via a resistor or potential divider, and these resistors sometimes go high or open circuit.

Decoupling capacitors are fitted between the screen grids of the valves and ground. Leakage here can affect the biasing, and possibly damage the related resistors. The failure of any decoupling capacitor can cause instability or distortion.

If the tuning crackles or is dead towards the high wavelength end of the scale, the fixed and moving vanes of the tuning capacitor could be touching. This is often caused by the vanes being slightly bent or damaged, or sometimes by dirt between the vanes. Crackles can be caused by dirty contacts to the moving section, which may be resolved by applying a soft brush in between the vanes in conjunction with a vacuum cleaner to remove the dust, and then a very light coat of thin oil to the slip contacts and bearings. Ensure the oil does not get into the vanes as it will drastically alter the tuning and is very difficult to remove. Seriously damaged tuning capacitors cannot be repaired, and should be replaced with a similar unit salvaged from another set.

The tuning capacitor mounting screws often pass through rubber grommets to damp vibrations from the speaker. These grommets can become brittle and crumble away, resulting in a loose mounting and tuning that varies if the chassis is moved. New grommets are available from component suppliers.

The mixer-oscillator and/or IF amplifier valves may be fitted with screening cans. If these are missing or making poor contact with the chassis, the set may be noisy or unstable.

Switch faults

A common cause of problems is wave-change switches. These can suffer from dirty, bent or even broken contacts which will render the set either very noisy or silent on one or more wavebands. Many problems can be solved with a little contact cleaner in the right place and possibly some gentle prodding to tighten the contacts.

On some sets with a gramophone input, a section of the switch is used to remove the HT supply to the RF and IF section. This switch section is prone to tracking due to the voltages involved. The effect is a continuous crackling or rustling sound, and the appropriate section can sometimes be seen arcing. The wires may be disconnected from the switch and permanently joined together, but some radio breakthrough may occur when the set is switched to the gramophone setting.

In the event of more serious switch failure, the only solution may be a complete replacement. This is a major undertaking however, and should only be considered when all the alternatives have been ruled out. Rotary switches can sometimes be replaced with a maka-switch type component, where the mechanism and wafers are purchased separately and assembled as required. With other switches, the only option may be to obtain a similar second-hand component from another set or a dealer.

You may be able to attach a modern switch to the existing mechanism, and transfer the appropriate connections to this. If all else fails, you may be able to get the set working on one waveband by disconnecting the defective sections, and permanently wiring the circuit.

VHF operation

Referring to the Bush circuit, V1a (ECC85) is a common grid RF amplifier. The anode load is tuned by means of variable inductor L4. V1b is the mixer-oscillator. L6, C10 and TC2 set the oscillator frequency. L6 is variable and is ganged with L4, to form the tuning control. The anode load of V1b is the first IF transformer.

The IF is usually 10.7MHz, although different values were used on a few earlier VHF sets (particularly those made before VHF broadcasts officially started). The figure will be given on the service sheet.

In some sets the tuning is adjusted by variable capacitors rather than variable inductors. The VHF tuner section is normally contained in a separate screened casing. This is mounted on the chassis, with the tuning adjustment mechanically linked to the AM tuning arrangement.

IF amplification, detection and AGC

The oscillator section of V2 is disabled in VHF mode, and the remaining section is used as the first IF amplifier. V3 and V4 are also IF amplifiers.

The FM detector is a ratio discriminator circuit, using two diodes in V5.

Correct operation of the circuit relies on precise adjustment of the final IF transformer. If the adjustment of any of the IF transformers is wrong the sound may be distorted. The mean level developed across C53 is used as the AGC control voltage. This varies the gain of V4, by varying the potential on the suppressor grid.

VHF variations

Many VHF sets have circuit arrangements very similar to the Bush, and use a similar valve line-up. Most have only one IF stage in addition to the AM mixer-oscillator valve.

Earlier VHF sets used a different circuit arrangement and valve types. The dual triode (ECC85) in the tuner assembly was replaced with two RF pentodes (EF80 or similar), with the first RF stage being configured as a common cathode arrangement. The IF amplifier used an EF86 or similar pentode valve. This valve gave lower gain than the later EF89 at the FM IF frequency, so a different value cathode resistor was often switched in to compensate. In a few cases the IF will be higher, possibly 19.5MHz.

Common faults

If some of the decoupling capacitors are suspect, the set may work fine on AM but suffer instability on FM.

The comments about arcing on the gramophone switch also apply to the section that removes the HT from the tuner unit when the set is switched to AM. This cannot be linked out as AM reception would be seriously impaired, so one of the alternatives given previously should be considered.

Since the tuner unit is often a separate assembly, it is possible for one of the connections between this and the main chassis to be broken resulting in the set being totally dead on VHF.

"Magic Eye" tuning indicator

V6 (EM81) in the Bush is a magic eye tuning indicator, and is driven by the AGC voltage. After considerable use, the tuning indicator will become dim, and will eventually reach a point when it does not glow at all. The only solution is a replacement. The tuning indicator is often mounted remote from the chassis, and may be attached to the speaker board of the set with a retaining spring stretched across behind it.

So how do these funny glass things work?

To those who have been bought up with transistors, valves can seem unnecessarily complex. This brief article will attempt to explain the workings of the valve in a clear simple manner - without the atomic theory and the maths!

A brief history lesson!

In 1883 Thomas Edison was experimenting with electric lamps. In his early experiments the glass bulb was becoming dull, and he wondered if this was due to particles being given off by the filament. He fitted a metal plate inside the bulb to attract these particles, and found that if the plate was at a positive potential a current would flow from the filament.

Later Professor Flemming found that current only flowed when the plate was positive, and that the arrangement could be used to rectify an alternating voltage. He patented this in 1904. Doctor Le de Frost discovered that, by placing a wire between the filament and plate, the current could be controlled.

Thermionic emission

When a metal is heated to a sufficiently high temperature in a vacuum, it will give off electrons. These will be attracted to any electrode that is at a more positive potential.

Most materials would melt by the time they are hot enough to emit a significant amount of electrons. Tungsten is an exception which gives good emission at 2300 to 2500 deg C, and melts at 3380 deg C. This would glow almost as bright as an electric lamp, which was a characteristic of early "Bright Emitter" valves. In more modern valves, the tungsten is coated with an oxide (such as barium or strontium) which gives good emission at around 700 deg C.

In most valves, the emitting conductor is a separate component to the heating filament. The emitting conductor is known as the "cathode", and is normally a thin tube. The heater passes inside the cathode and is electrically insulated from it. This is known as an indirectly heated cathode. Some valves have directly heated cathodes, where the heater and cathode are the same component. These were frequently used in battery sets.

Electron flow vs conventional current flow

We are now used to thinking of current flowing from positive to negative. However, current is actually a flow of electrons in the opposite direction. This is the result of an incorrect assumption by early scientists which has become established - hence we have the separate terms "Electron Flow" and "Conventional Current Flow".

To avoid confusion (hopefully!), think in terms of electron flow when considering the actual workings of the valve, and current flow when thinking about the circuit.

The diode

The electron collecting plate is known as the "anode". It normally consists of a cylinder of metal around the cathode, a few millimetres away.

When the anode is at a positive potential relative to the cathode, current will flow. This is useful for detection and rectification, but is obviously incapable of amplification.

A rectifier valve has larger, more substantial electrodes than a detector, to cope with the much greater currents involved. Figure 1 shows a rectifier valve circuit with an AC input and a half-wave rectified DC output.

A smoothing capacitor would normally be connected across the load (Rl) to give a relatively steady DC supply. The load would normally be the remainder of the circuit rather than a single resistor.

The valve electrodes are indicated by the normal abbreviations - "a" for anode, "k" for cathode and "h" for the heater connections. A heater supply is not shown in the diagram for simplicity.

The triode

By adding a spiral of wire between the cathode and the anode it is possible to control the current flowing between them. This spiral of wire is known as the "control grid".

Referring to figure 2, if a varying signal is applied to the control grid (g1) via C1, the anode current will vary in sympathy. By placing a resistor (Ra) between the anode and the positive supply, the varying current will be converted to a varying voltage on the anode.

In normal use, the control grid will not be at a positive potential relative to the cathode, otherwise it will act as another anode and draw current (known as grid current). It is normally biased a few volts negative (although some triodes are designed to be biased at 0V). In very early radio sets a separate grid bias battery was used, often having several tappings to give different bias levels - but this was quickly superseded.

Usually, cathode biasing will be used. Instead of connecting the cathode directly to ground (0V), it is connected via a low value resistor (Rk). This will drop a few volts, so the cathode will be a few volts positive.

The control grid is at a high impedance and draws virtually no current. It is normally connected to ground via a high resistance (Rg), and the signal is coupled via a capacitor (C1).

If Ck is omitted, the voltage at the cathode will vary with the anode current. This causes negative feedback which gives a reduction in gain (and also reduces distortion). Ck is fitted to obtain the maximum gain from the stage, and has a low impedance over the signal frequency range. Triode valves are mainly used for low level audio amplification.

Their use is limited at radio frequencies because of the capacitance between the control grid and the anode. Although this is only a few pF, the "effective capacitance" is approximately equal to this value multiplied by the stage gain. This effective capacitance becomes the input capacitance of the stage, and has a drastic shunting and detuning effect on a radio frequency signal.

The tetrode

The tetrode was a development of the triode. A second grid is placed between the control grid and the anode. It is known as the "screen grid", and acts as an electrostatic screen, the purpose being to minimise the capacitance between the control grid and anode.

For this to work it must be connected to ground at signal frequencies. If it were connected directly to 0V it would act as another control grid and greatly reduce the anode current. It is therefore often connected to the HT rail via a resistor to drop some voltage, and decoupled to 0V with a suitable capacitor.

The tetrode solves the capacitance problem allowing operation at high frequencies, and also gives greater gain. However, it introduces another problem - distortion. This is caused by secondary emission, which is too involved to describe in this brief article. Consequently, tetrodes are seldom used, but it is included here because it is an important stage in the development of a better solution.

The pentode

As its name implies, the pentode has five electrons. Four of them are the same as those in the tetrode, namely the cathode, control grid, screen grid and anode.

To suppress the secondary emission a further grid, known as the "suppressor grid". This is normally connected to the cathode, often internally within the valve envelope, but sometimes a separate connection is provided.

The result is a valve that retains the advantages of the tetrode - high gain and operation at high frequencies - without the distortion. Pentodes are commonly encountered in RF and IF amplifier stages, and in amplifier power output stages.

Figure 3 shows a basic pentode amplifier stage. This is fairly similar to the triode circuit discussed previously, with the addition of the connections to the screen and suppressor grids (g2 and g3).

Vari-Mu valves

It is often necessary to be able to control the amplification (gain) of a valve either manually or automatically. This is commonly required in the AGC (Automatic Gain Control) circuits in radio receivers.

The spacing of the wires that make up the control grid vary, being closer together at the centre and wider apart at the ends. By varying the negative voltage on this grid, the gain can be adjusted.

Pentode power amplification

Figure 4 shows a typical Class-A pentode output stage. The anode load resistor is replaced with the primary of the output transformer (T1), which drives the loudspeaker (LS1). The purpose of the transformer is to convert the relatively high anode impedance of the valve to the low impedance of the speaker.

Since the output transformer is inductive, its impedance varies with frequency giving an uneven frequency response. A capacitor (Ca) is often connected in parallel with the transformer primary which corrects this to a great extent (this is sometimes referred to as "tone correction"). In some cases, more than one capacitor is used, together with series resistors to give more accurate correction.

The screen grid (g2) is shown connected to the HT supply after a decoupling resistor (Rd). This is a common arrangement in valve radio receivers.

A resistor is placed in series with the control grid (g1). This works in conjunction with the input capacitance of the valve to attenuate the high frequencies (above the audio range) to ensure stability.

Many hi-fi amplifiers and some more expensive valve receivers use a Class-B push-pull output stage. This is an involved subject in its own right and will not be covered in this brief article.

A higher quality output transformer is normally used in conjunction with negative feedback, which makes impedance correction capacitors (such as Ca) unnecessary.

Other valve types

A number of special-puropse valves have been produced with a greater number of electrodes. Hexodes, heptodes and octodes are sometimes used in mixer-oscillator stages. The operation of these valves is rather complex and I will not attempt to describe them here!

Combined valves

Often more than one valve section is contained in a single glass envelope. These sections normally share the same heater connections and are sometimes interconnected.

For example, the Mixer-oscillator valve in radio receivers often consists of a hexode (or similar) and triode sections in the same envelope.

The triode is used as the oscillator section and the hexode acts as the mixer and amplifier. The two sections may be connected internally within the valve, or externally.

Further reading

Those requiring an in-depth discussion of valve operation are advised to refer to the excellent series entitled "Valve Technology" by Graham Dixey, published in "Electronics - The Maplin Magazine", issues 67 to 73.

Mullard valve type numbering

The standard format of the Mullard type number as printed on Mullard and equivalent valves comprises two or more letters followed by a group of up to three numbers.

AUDIO OUTPUT LEVEL INDICATOR

A handy little project from Paul Stenning to help with antique radio restoration

This unit is designed for monitoring the audio output level across a loudspeaker when carrying out alignment of radio equipment. As no great precision is required, a simple passive circuit arrangement has been used.

The meter will read full scale with about 1 Watt onto a 3R speaker, although the calibration (and indeed linearity) are not important for the intended use.

The unit was designed to accompany the Valve Radio Repair and Restoration series, but will also be useful for aligning transistor equipment. It may have other applications for measuring audio power levels, providing some non-linearity is acceptable.

Circuit Description

The circuit is a voltage doubling rectifier driving a panel meter. The input signal is AC coupled via C1. D1 holds the signal so that the negative peaks are at ground potential.

The mean level is above ground, so the polarity of C1 is important. The peak level is rectified by D2 and stored in reservoir capacitor C2.

The value of R1 has been selected to give the required calibration with a 250uA meter movement. If a 100uA is used, the alternative component values should be used. Germanium diodes are used because of their low forward drop voltage. If silicon diodes were used the unit would be less linear.

Construction

The prototype was constructed using a small piece of plain matrix board. Tag strip or stripboard could be used if preferred. A PCB would be over-kill for such a simple design!

The meter used on the prototype was a low cost 250uH signal strength meter obtained from Maplin (Order Code LB80B). This is marked "SIGNAL" and has an arbitrary scale marked 0 to 5, making it ideal for the purpose. A higher quality meter could be used, but this would offer no real advantage.

The completed circuit may be fitted into a small plastic case. The circuit board may be retained by using short rigid connecting wires to the meter. The input may be bought in via a length of two core speaker cable. The free end may be fitted with a pair of small crocodile clips for easy connection to the speaker tags in the radio being aligned.

In Use

The unit is designed for connection across a loudspeaker. If you wish to disconnect the loudspeaker because of the annoying noise, replace it with a suitable wirewound resistor.

Unless stated otherwise in the service information, the correct alignment point is that which gives the greatest reading on the meter.

Fig.1

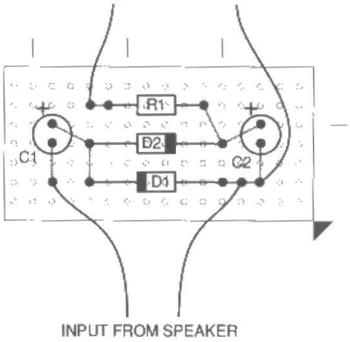
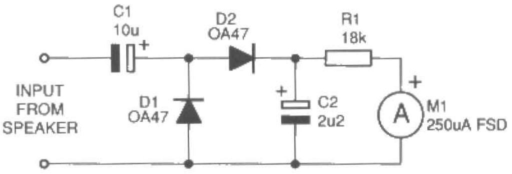


Fig.2

METER INDICATES FULL SCALE WITH APPROXIMATELY 1 WATT INTO 3Ω SPEAKER



ALTERNATIVE COMPONENT VALUES
IF M1 = 100uA THEN R1 = 47k AND C2 = 1u

PARTS LIST

R1 18K 0.25W Resistor

C1 10uF 25V Electrolytic Capacitor

C2 2.2uF 25V Electrolytic Capacitor

D1 OA47 Germanium Diode

D2 OA47 Germanium Diode

M1 250uA Panel Meter

Plain matrix board

Case

Speaker wire

Croc clips (2 off)

3R3 2.5W wirewound resistor (optional dummy load)

Note: If a 100uA meter is used, C2 should be 1uF and R1 should be 47K.

Practically Speaking

BY TERRY BALBIRNIE

This month we shall continue looking at some practical points which make for good circuit-building. This follows from my observations of GCSE coursework over several years.

I have seen projects involving the use of potentiometers and rotary switches where the spindle has not been cut down to size. The control knob therefore stands above the work giving a very amateurish appearance (see photograph). In exam work, it seems that candidates are hesitant to cut the spindle and think it safer to leave it as it is. More usually, they have not planned ahead. They secure it in the case and wire it up so that it then becomes very difficult to cut without damage either to itself or to the rest of the circuit.

Giving support

Always cut the spindle of a potentiometer or rotary switch before installing it. Think carefully about the type of control knob which is to be used so that no more spindle than necessary is cut off. A good method is to fit the component temporarily, measure how far the control knob stands above the surface allowing for clearance, then cut off this amount. The best way to cut it is to grip the spindle (not the body) in a vice then, supporting the body with one hand, cut the spindle gently using a sharp hacksaw. The top may then be filed smooth.

I have seen numerous projects where a potentiometer operates in the wrong sense. For example, a volume control should provide increased sound output as it is turned clockwise. If it works the other way, all that is needed is to reverse the connections to the outer pair of tags.

Rotary switches of the most popular type are often left with more physical positions than are needed. The redundant ones give the final device an amateurish feel. While checking GCSE circuits I have been amazed by the number of candidates who are unaware that this type of switch is adjustable. Any number of positions up to the nominal value may be selected - thus, in a six-position switch, two, three, four, five or six positions may be obtained.

Going nuts

To adjust it, first remove the large brass nut used for securing it to the panel. Underneath will be found a metal tab washer. This is removed by tapping the end of the spindle sharply on the work surface. If this does not work, a thin blade should be used to gently prise it from its seat. It will be seen that there is a circle of holes numbered 2 to 11 - ten holes altogether - and the tab may be inserted in any one of these.

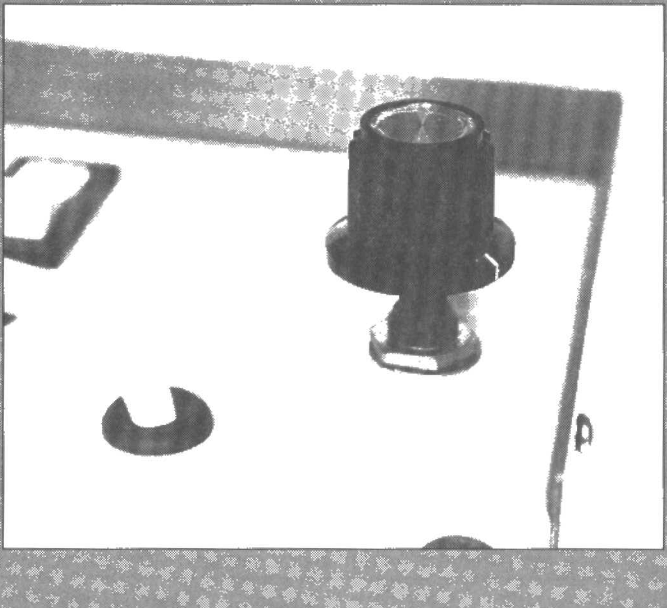
To adjust the switch, first turn the spindle fully anti-clockwise. Replace the tab washer in the hole marked, say, 3. When re-assembled, the switch will be found to have only three positions. A 12-position switch is supplied having only 11 positions. This has puzzled many people - sometimes they have returned the switch thinking that the wrong one was sent. Since there are only 11 holes, to obtain 12 positions the tab washer is removed and discarded.

While on the topic of this popular type of rotary switch, note that there are four different configurations - single-pole 12 position, two-pole 6 position, three-pole 4 position and four-pole 3 position. Some switches have a break before make action (the previous connection being interrupted before the next one is made) some make before break.

Round peg, round hole

A small peg projects from the body of the switch close to the tab washer position. There is sometimes a similar lug on a potentiometer. This would prevent it from butting up to the panel so many people simply cut it off. However, it is a locking lug and a hole should be drilled in the panel for it to rest in (the control knob will hide this hole). Without it, the securing nut is likely to loosen allowing the switch rotate and tear off the connecting wires.

Although they are very versatile, these switches have a limited switching capability. I have seen candidates using them to control motors and for other high-current applications. The result is a rapidly burnt out switch! They are only supposed to switch about 150mA. However, there is a trick which may be used here. Although they can only switch a very small current, the contacts can carry a much larger one. If the supply is switched off, the rotary switch may be moved to a new position then the supply switched on again.



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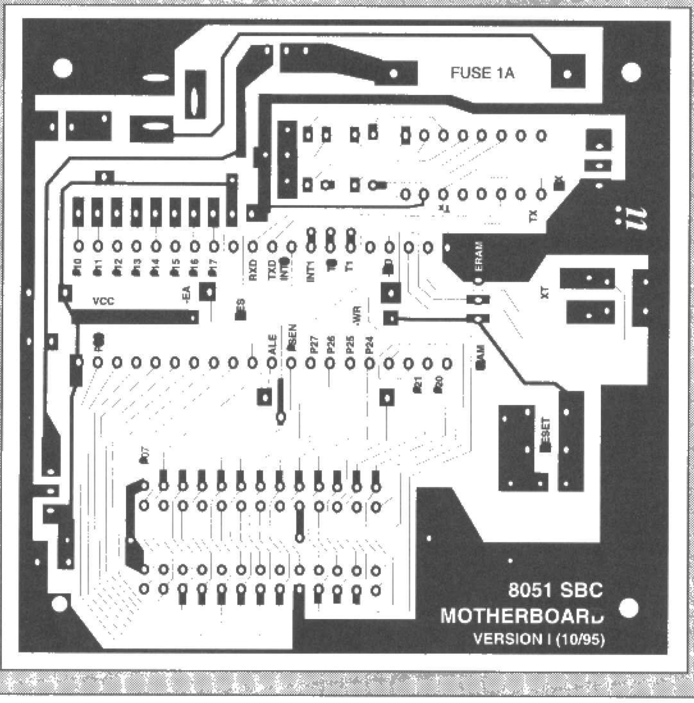

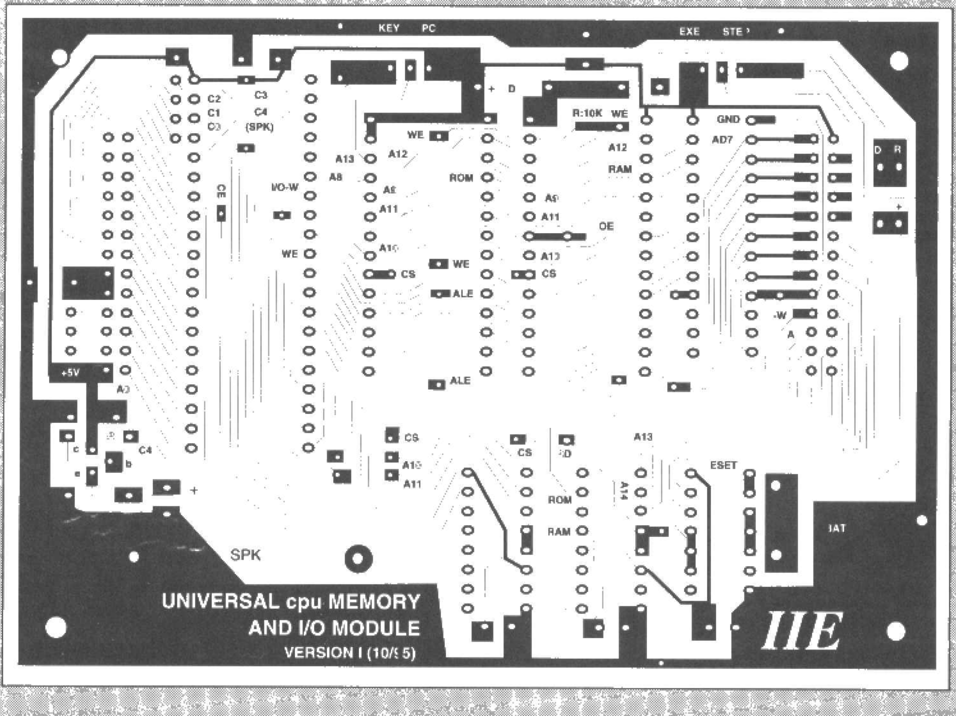

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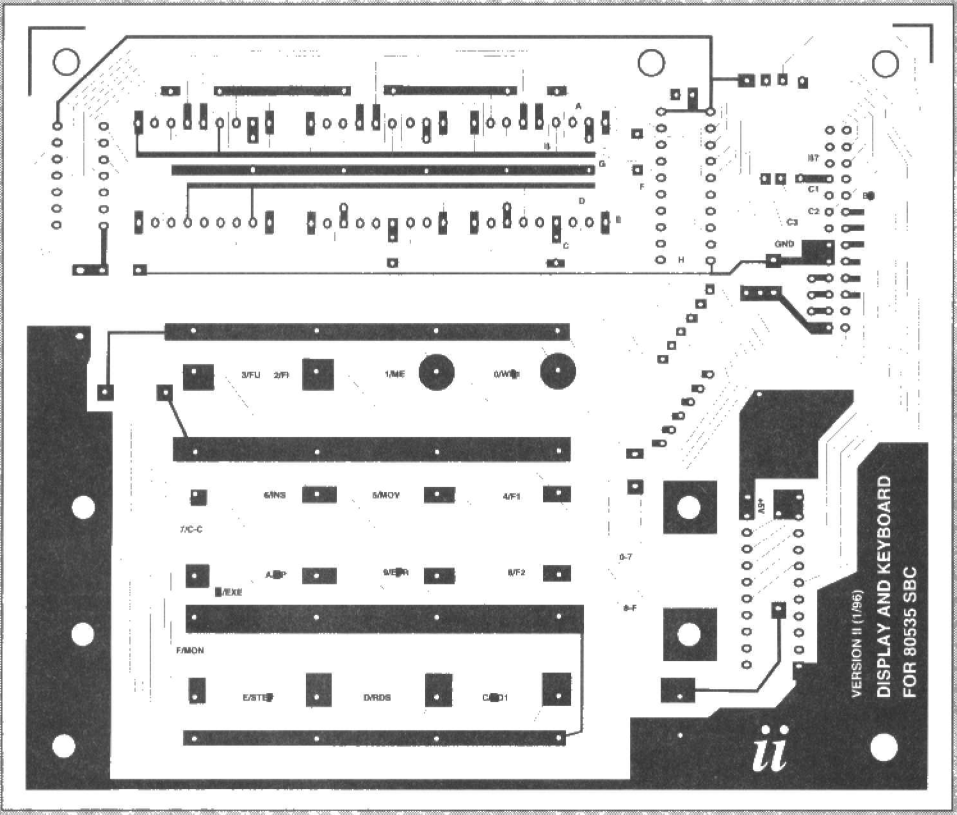

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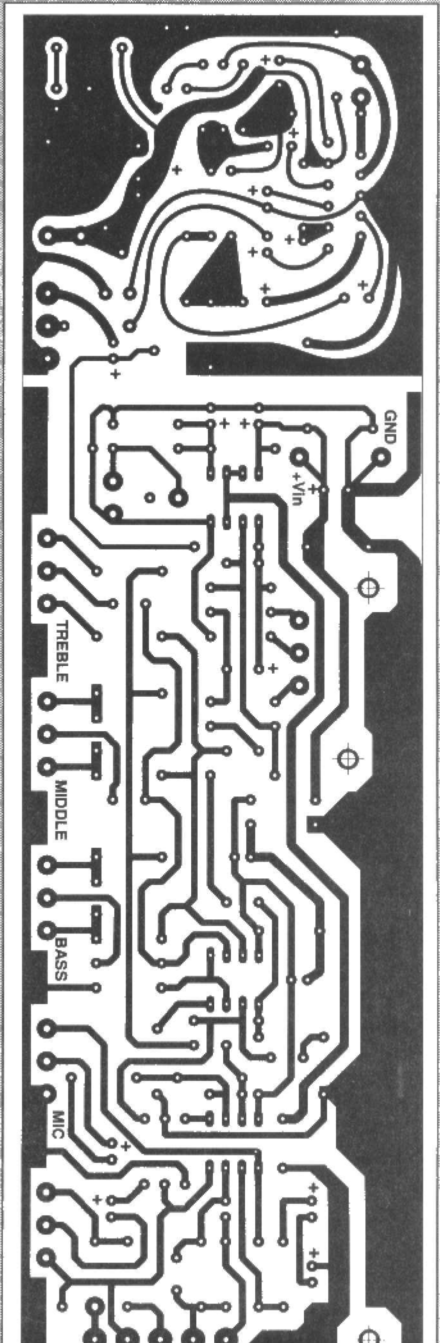
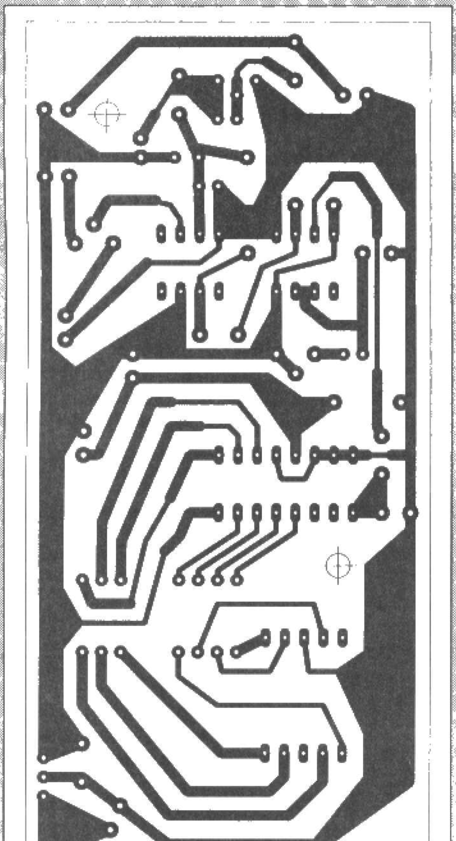


SOUND TALLY



Around the Corner

The concept of a 'hobby' is fairly recent, in fact it is little more than a hundred years old. In the nineteen thirties, forties, and fifties it seems that everyone had a hobby, young and old, male and female. Hobbies that ranged from model aircraft and photography, to electronics, woodworking, and needlecraft. But if current indications are anything to go by, it seems that the conventional concept of a hobby may not survive beyond the turn of the century.

The popularity of hobbies came about because of increased prosperity, largely thanks to the application of technology, coupled with the availability of education for everyone. The result was that reasonably large numbers of people, mostly middle class and skilled working class, had, what was then, the luxury of spare time and money beyond that needed to feed, clothe, and house them.

The colossal explosion in new technology in the first half of this century also helped to fuel the interest in hobbies, the hobby element being reinforced by the fact that there was no consumer product market. It was virtually impossible to buy a radio or TV in the very early period of their development, at least not without spending a fortune. The same was true of flying, motoring, and photography.

This meant that people interested in these new technologies had to resort to making things for themselves. Early photographic enthusiasts, for example, had to resort to making their own cameras, and even their own film, and until quite recently had to develop the film, enlarge it and make prints themselves. Doing it yourself was the only way to do it.

The same applied to radio and TV, nearly all the early sets were hand made by the user. To cater for this market, books and magazines appeared which told the interested individual exactly what to do, plus a host of small businesses founded to supply the necessary components and materials. Thus was born the hobby in the form that we have known it over the last 50 or more years.

The development of a powerful consumer goods industry has, however, destroyed this foundation upon which so many hobbies were built. I know of few people who, today, would sit down and build a radio or TV from scratch. It is far easier and cheaper to buy a ready-built commercial product.

This is a pattern which has been repeated within the last 20 years in the personal computer industry. Before the IBM PC, or the earlier Commodore PET and Apple II, individuals were forced to design and build their own systems, or at very best assemble it from a kit. Today, unless you have a very special application in mind, that requires a very special architecture there is no point whatsoever in designing and building your own computer from component level.

The consumer goods industry, by giving people cheap, ready-built and designed products using the latest technology, has thus removed one of the prime incentives for people becoming involved in a hobby. This has happened with computer software; as recently as five years ago people were learning to programme, and were writing programmes themselves because they wanted something that was different and better than the commercial products. The market satisfied that need, and in so doing destroyed the incentive behind the hobby.

Even more recently we have the fact that enthusiasts, in other words hobbyists, developed and created the Internet, but they are currently losing it to commercial interests.

As business becomes more competitive, and quicker to adopt new technology, so the time frame in which the hobbyist can be active becomes more and more limited. At the same time, the technology involved becomes more and more complex, and more and more expensive. At the same time designers are pushing the user further and further from the technology, with highly integrated circuits, and sealed units. No longer can one learn how they work by taking them apart. Gone is another area of pleasure for the hobbyist.

These, and other factors such as cost of tools and equipment, plus shortage of space in smaller houses, are inhibiting the hobbyist. Magazine, book, kit and component sales are just a fraction of what they were 30 years ago. It is not that people are not interested, it is just too hard, and too expensive, and there just is not the incentive to overcome those constraints.

So, is there a future for hobbies, such as electronics? In its traditional form, I think not. But leisure time and small surplus income are everyday facts of life for most of us. Most of us do not want to spend our lives working and watching TV, we want to do something interesting and creative; the hobby is just going to take a new form.

I shall be examining how I see hobbies evolving in next month's Open Forum. In the meantime if you have any ideas about this subject I would love to hear them.

Next Month......

In the July 1998 issue of Electronics Today International we continue Paul Stenning's look at restoring antique electronics, whilst from Terry Balbirnie there is a project to build a simple, easy to use burglar alarm system.

Bart Trepak introduces another PIC micro controller project, whilst Dr Pei An will conclude his 8051/80535 single board computer project. From Barry Porter there is the start of a project to build a sophisticated and versatile PIC based process controller.

The main feature articles will include a look by Douglas Clarkeson at the technology and application of wave power. There will also be a short feature on setting up your own radio station.

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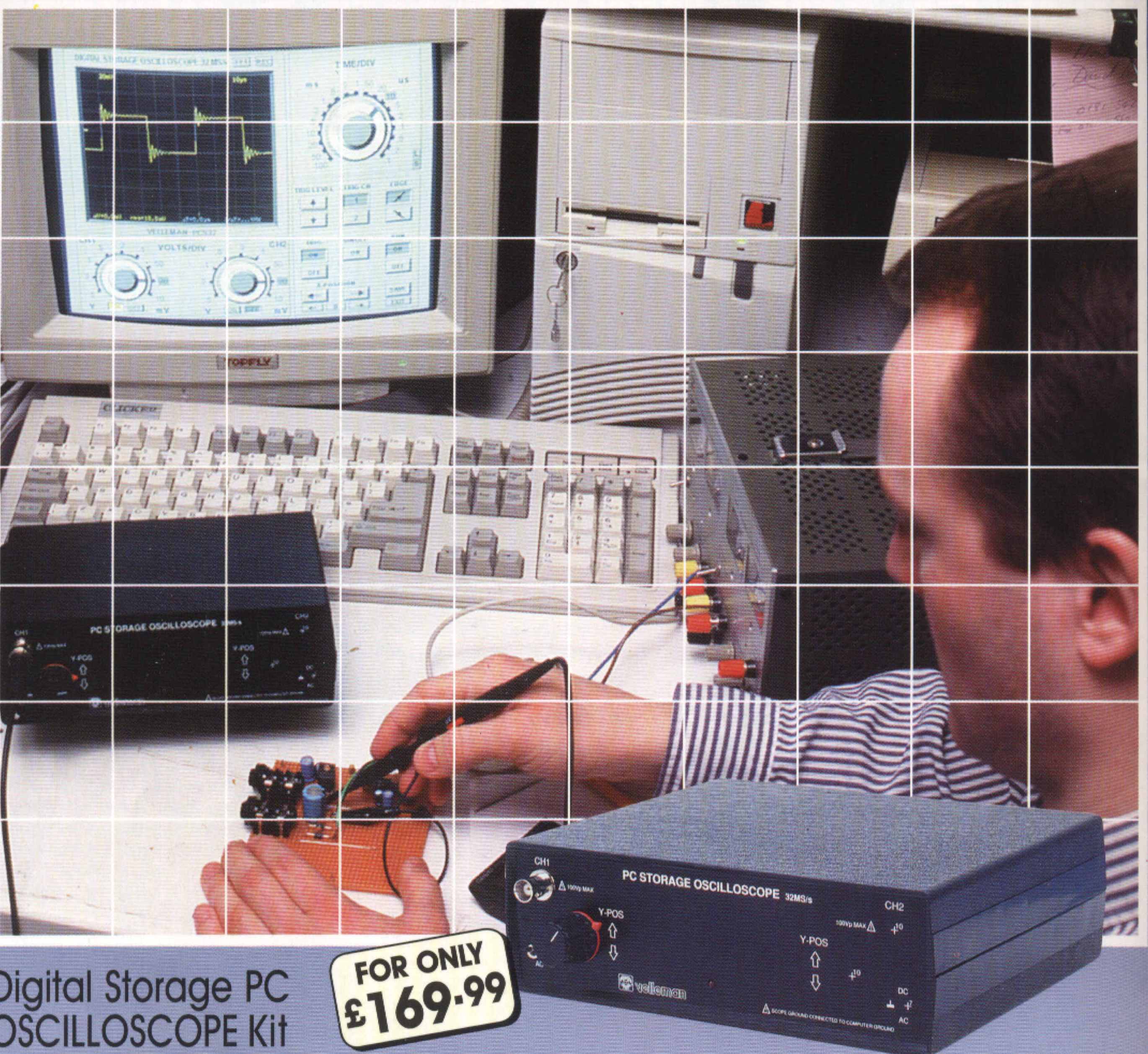

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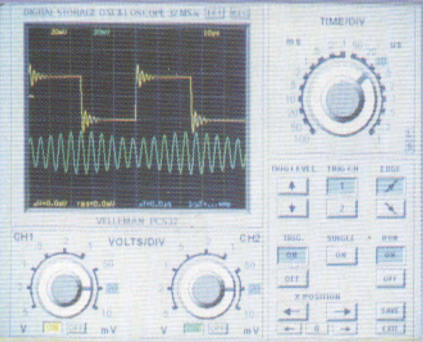

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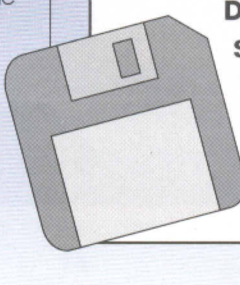

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